Fractures and Dislocations

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CLINICAL MANUALS

FOR

PRACTITIONERS AND STUDENTS

OF MEDICINE.

FRACTURES AND DISLOCATIONS.

BY

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PREFACE.

THE object which I have endeavoured to keep steadily in view in writing this manual is, that it should be essentially clinical, and I have sought to present to my readers a concise and practical treatise of the causes of the various common Fractures and Dislocations, the signs by which they may be recognised, and the appropriate treatment to be adopted for their cure.

In doing this I have, in order to keep my subject within reasonable limits, been compelled to be, to a certain extent, dogmatic; and while endeavouring as far as possible to acknowledge the opinions of others, I have for the most part laid down those rules for guidance, as regards the symptoms and treatment, which I have, from my own experience, found to be most efficacious as the result of my practical experience in the wards of St. George's Hospital.

That my opinion and treatment must in many instances differ from that of other surgeons cannot be doubted, and is to be expected; but if I have succeeded in producing a treatise which shall prove a trustworthy guide to the practitioner of medicine and surgery in

dealing with the common forms of fractures and dislocations which may come under his notice, and at the same time a treatise for the student which shall enable him to obtain a clear and comprehensive knowledge of the subject, the ends I have had in view will be accomplished, and I shall feel amply rewarded for my labour.

My best thanks are due to Mr. Charles Berjeau for his skilful illustrations. Most of these have been drawn from preparations in the museum of St. George's Hospital; some few have been copied from familiar sources, which have been duly acknowledged.

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Portman Street,
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Section I.

GENERAL PATHOLOGY OF FRACTURES.

CHAPTER I.

CAUSES OF FRACTURES.

The word fracture (fractura—frango, fractum; to *break*) signifies the act of breaking; especially the breaking of any hard body, and is applied in surgery to the breaking of a bone into two or more fragments. A fracture has, therefore, been defined as "a sudden and violent solution of continuity of bone." This does not, however, quite express the whole state of the case, since it is customary, and no doubt convenient, to class instances of separation of epiphyses from the shaft of a bone and separation of the costal cartilages from the ribs as cases of fracture, though they are not "solutions of continuity" in a bone, but rather separation or disunion of two bony, or bony and cartilaginous, surfaces from each other.

Fractures are always the result of some local strain or injury, though the amount of injury may vary very much, from a slight muscular effort to severe external violence; certain predisposing causes rendering fracture more liable to occur in one case than another.

We must consider the causes of fracture, therefore,

under two heads: first, the local or exciting causes, and secondly, the predisposing or constitutional causes.

Local causes.—These are of two kinds, either the application of external violence (much the more frequent cause), or muscular action.

Fractures from the application of external violence may be caused either by direct or indirect force. A man gets a severe blow on some bone, the bone gives way at the point struck, and the fracture is said to occur from *direct* violence.

When, on the other hand, a bone is compressed between two opposing forces, and gives way at its weakest part, it is said to occur from *indirect* violence. Here the bone first bends and then breaks, when it is bent beyond what its elasticity admits of, just in the same manner as an elastic column first bends and then breaks, if pressed upon by a superimposed vertical weight. Any part of a bone may be the seat of a fracture from direct violence, whereas those from indirect force occur at some particular point.

Muscular contraction may be the cause of fracture. The most frequent example of this is seen in the patella from violent contraction of the quadriceps extensor cruris. Other bones are, however, occasionally fractured from the same cause. Of these, the humerus is frequently broken in the act of throwing, or the olecranon may be separated from the shaft of the ulna by the violent contraction of the triceps. The posterior part of the os calcis may be torn off by the action of the muscles of the calf, and other bones are sometimes, though rarely, broken by muscular contraction.*

* For illustrative cases, *see Medical Times and Gazette*, vol. ii., p. 85, 1857; ibid., August 15, 1857; Cooper on "Fractures and Dislocations," p. 339, 1842; *Lancet*, vol. i., p. 271, 1867; *American Journal Medical Science*, p. 277, January, 1871; *British Medical Journal*, vol. ii., p. 513, 1872; Humphrey on "The Human Skeleton," p. 9; Holmes on "Principles and Practice of Surgery," p. 242, 4th ed.

Predisposing causes.—The causes which predispose or conduce to fracture are numerous and varied. They may be conveniently considered under three heads :

I. Natural causes pertaining to the individual.
II. Diseased conditions of the individual (cachexia).
III. Causes confined to the bone.

I. **The natural causes pertaining to the individual** may be classed as (α) hereditary fragility, (β) age, (γ) sex.

Hereditary fragility of the bones appears to exist in certain individuals, so that the bones fracture from the slightest injury, or even from muscular contraction, and this tendency to fracture appears to be transmitted from parent to offspring through successive generations. The author recently saw a lady who had fractured her thigh from muscular contraction. The patient's mother, æt. forty, sitting at dinner, bent over her chair to pick up something she had let fall. She slipped and fractured her humerus. The grandmother, æt. eighty-four, was standing on one leg putting a shoe on the other foot, and slipping, fractured the neck of the femur. The great-grandmother, æt. seventy-nine, slipped in her bedroom and fractured her thigh. No male of the family was known to have suffered from fracture.

Age has a very decided influence on the production of fracture. The most common age for fracture to occur is from twenty-five to sixty. In early life the bones are pliable and elastic, and bend to a much greater extent (before they break) than later in life, when they contain more earthy salts, and are therefore more brittle. Moreover, children when they fall, do so lightly, and thus fractures are not so commonly produced ; nevertheless, Malgaigne has pointed out

that between the ages of two and four there is a greater tendency to fracture than after four. During this period of a child's life he is learning to walk, and hence his falls, sometimes resulting in fracture, are freqnent. After four the child becomes more firm and steady on his legs, falls are less frequent, and injuries to his bones become less common.

From this time the relative frequency of fracture goes on steadily increasing till about the age of fourteen or fifteen, when the rough games of school-boy life in the better classes, and the commencement of hard work and exposure to accidents among the poorer class, send up the proportion of fractures to a considerable extent. Another increase occurs about the age of twenty-five.*

In old people the bones are fragile, and easily broken, on account of the thinning of the cortical substance and enlargement of the medullary canal; but, nevertheless, fractures, with the exception of intracapsular fracture of the neck of the thigh bone, and Colles's fracture of the radius, are not common, because, on account of their inability to engage in hard work, old people are not exposed to the same chances of accident.

Sex.—As might naturally be supposed, fractures are much more common in the male than in the female. The former, being compelled to undertake hard and laborious work, are much more exposed to risk of injuries of all sorts, and fractures in particular.†

After the age of forty-five, however, fracture is said to be as common in the female as the male, on account of the great frequency with which two special forms of fracture occur in women of advanced life;

* On this subject the reader may consult Malgaigne, "Ann. d'Hygiène Publique," tome xxii.

† On the strength of different bones in men and women, *see British and Foreign Med.-Chir. Review*, vol. ii., p. 77; 1860.

namely, fracture of the neck of the thigh bone, and fracture of the lower end of the radius.

From Flowers' tables it appears that fractures of the upper extremity are as common in girls as in boys up to the age of five years. After this the proportion in males steadily increases.

II. **The diseased conditions of the individual or cachexiæ** predisposing to fracture are very numerous. Of these, undoubtedly the most common are mollities ossium and rickets. Scurvy, syphilis, scrofula, and some influences of the nervous system, may also be ranked as not unfrequently predisposing to fracture; while gout must be looked upon as possibly predisposing to this injury, though the evidence in favour of this view is by no means conclusive.

Mollities ossium or **osteo-malacia,** when it occurs, strongly predisposes to fracture. Fortunately, the disease is not of frequent occurrence, and, therefore, the cases of fracture arising from this cause are not numerous. The remarkable changes in appearance and texture which the bones undergo in true mollities ossium sufficiently explain their liability to fracture.

Rickets produces a condition of the bones which disposes them to fracture, and not only this, but on account of the unsteadiness of gait of rickety children, and their proneness to fall, the accidents which occasion fracture are more liable to occur in them than in healthy children. So that from the pressure exerted upon them, or even from muscular action, the bones of a rachitic child are often broken, and it is not uncommon to find several broken in the same patient, or it may be the same bone broken in more than one place.

Scurvy is believed to produce softening of the bones, under which circumstance fracture may occur, sometimes from very slight causes. It is stated also that after the union of a fracture, should the patient

develop symptoms of scurvy, the union may give way, and the bone become refractured.

Syphilis, in its tertiary form, is a predisposing cause of fracture, though not one of very frequent occurrence. The fracture appears to be the result of local changes taking place in the bone, rather than the result of any general syphilitic softening, such as that described by A. Paré, who says that "syphilis liquefies the bones as if they were melted metal." That is to say, the fracture is the result of thinning of the bone from interstitial absorption,* produced by the presence of a gummy tumour.

The influence of the nervous system, in predisposing to the occurrence of fracture, appears to act by producing special conditions of the bone tissue owing to changes of structure, which result in atrophy and brittleness.

Attention has been drawn to this subject from the frequent occurrence of fracture of the ribs in the inmates of lunatic asylums.

Dr. Boddington describes the softened and brittle condition of bones in the insane, and states that they are so soft that they can be cut with a knife. He believes that the softening is most common in motor paralytic disorders, connected with sclerosis of the nerve centres from increase of connective tissue, such as general paralysis of the insane, paralysis agitans, and locomotor ataxy.†

The condition of the bones in a case of acute mania, and in another of general paralysis, are described by the late Dr. Omerod.‡ He states that the process is one of absorption, the tissue being replaced by an excessive deposit of fatty matter.

And Mr. Rogers and Dr. Brown prove by analysis

* *See* a case, *British Medical Journal*, April 17, 1869.

† *British Medical Journal*, January, 1871; p. 105.

‡ St. Bartholomew's Hospital Reports, vol. vi., p. 65.

that "the ratio of organic constituents to earthy matter is much greater, while the ratio of lime to phosphoric acid is distinctly less." *

Though this morbid condition is more marked, and was first observed in the ribs of insane persons, it nevertheless affects the other parts of the osseous system, though to a less degree, so that all the bones are liable to fracture from apparently slight accidents.

Epilepsy was in past times believed to be a common cause of brittleness of bones, leading to their fracture from slight accidents, and cases are recorded where patients have broken their bones during a fit.

Probably in these cases the fracture has been produced by some violence inflicted by the patient on himself during the convulsions, the bones being naturally weak and fragile from the debility induced by the disease, or else from the epilepsy being complicated by insanity.

With regard to **scrofula,** there is no doubt that secondarily this cachexia is a frequent cause of fracture. That is to say, it induces certain changes in the bones which lead to this injury.

Thus, diffuse periostitis frequently occurs in and appears to be intimately connected with a scrofulous diathesis. This inflammation leads to necrosis, and the necrosis results in fracture. Again, struma may favour fracture by inducing a condition of caries, which, gradually destroying the bone, weakens it at one point, and then from some slight injury fracture may occur at this part. These conditions will be more conveniently considered in the next section.

Gout has been regarded by some as a predisposing cause of fracture, but there does not appear to be sufficient evidence to prove that this is a very general or potent cause.

* Liverpool Medical and Surgical Reports, vol. iv., p. 85.

III. **Causes confined to the bone.**—Under this heading will have to be considered :

(1) The liability of different bones to fracture.

(2) The various local changes which take place in a bone, and which, by weakening it, predispose it to fracture.

(1) As regards the liability of different bones to fracture, it must first be noted that, as would naturally be expected, the bones on the right side of the body are more commonly fractured than those on the left, since they are more exposed to violence.

The situation of a bone may be a predisposing cause of fracture, from its being more exposed to injury; thus, the long cylindrical bones of the extremities are more frequently fractured than the bones of the trunk.

The shape of a bone has also some influence on its tendency to fracture; thus, a long bone is more frequently broken than a short one.

(2) The various local changes which take place in a bone and predispose it to fracture are atrophy, caries and necrosis, and new growths.

Atrophy of bone predisposing to fracture may occur in several ways. It may be simply the atrophy of old age, or may occur from disuse of a part. As for instance, in cases of hip joint disease, when the limb has not been used for a long time in progression, the femur may become so wasted and atrophied that it will give way under the slightest force employed to straighten the joint.

Atrophy of bone may also follow deprivation of blood supply. Mr. Curling has pointed out that atrophy of a fractured bone follows if the direct supply of blood by the medullary artery is cut off.* The same thing is shown in a preparation in the Hunterian

* Med.-Chir. Trans., vol. xx.

Museum (No. 382a). Mr. Durham relates an interesting case bearing on this point.*

In this instance he believes that degeneration and absorption of the bony matter took place as the result of a blow, until the bone became so thinned that it gave way under the slightest strain.

It seems probable that the injury involved some interference with the nutrition of the bone, and a deficient supply of blood was the primary cause of this change.

Caries and necrosis are undoubtedly predisposing causes of fracture. The bone, being weakened by the death of a part of its osseous tissue, is no longer sufficiently strong to withstand the effect of a slight strain, and gives way at the seat of disease. Mr. Morrant Baker narrates an interesting case of fracture of the femur, the result of necrosis of nearly the whole of the shaft; the death of the bone being unattended with suppuration;† and Rosenberger a case in which complete bony union took place in six weeks after spontaneous fracture of the femur from caries.‡

But by far the most frequent predisposing cause of fracture confined to an individual bone is the presence of a new growth, either infiltrating the bone tissue or pressing upon it and producing absorption. Of the former class, sarcomatous tumours affecting the bone and producing fracture are to be found in every hospital museum, and recorded in the Transactions of the various societies.§ Instances of spontaneous fracture following extensive ulceration from epithelioma are also to be found recorded. Thompson mentions a case in a patient, aged 69, who

* Clin. Soc. Trans., vol. iv., p. 63.

† Med.-Chir. Trans., vol. lx., p. 187.

‡ *Berliner Klinische Wochenschrift,* April 6, 1874.

§ *See,* among others, Path. Soc. Trans., vol. vi., p. 296; vol. x., p. 235; vol. xi., p. 212. Med.-Chir. Trans., vol. xv., p. 186; vol. xvii., p. 51.

had suffered from an ulcer of the leg caused by injury, for fifty years, which eventually became epitheliomatous. Both bones suddenly snapped while the patient was sitting up in bed.*

Finally, hydatid disease of bone, by excavating it, has a tendency to weaken it, and thus predispose to fracture.

The consideration of the causes of fracture would not be complete without some allusion to the subject of intra-uterine fracture. These fractures are generally produced by some external violence applied to the abdomen of the mother during pregnancy; thus, a violent blow, a fall down stairs, or a fall from a window, may produce a fracture, generally of one of the long bones, of a *fœtus in utero*; they may be simple or compound. They are usually accompanied by great distortion, and if compound the protruding bone may injure the uterus, producing abortion. Otherwise the mother may go to the full time, and the fracture be found to be united in a distorted position, or no union may have taken place. Carus relates a case in which the injury occurred at the sixth month, and the child was not born till the full time. Intra-uterine fractures are also said to occur, without external violence, by the violent action of the fœtal muscles.

Another class of fractures, which have been termed *intra-uterine*, may occur during parturition, from violence in the act of delivery. These are generally situated in the skull and are incomplete, being produced by pressure from the forceps during the passage of the head through the pelvis. The long bones of the extremities may, however, be fractured by violent traction, or disunion of the epiphyses may take place.

Finally, there is another variety of intra-uterine

*Path. Soc. Trans., vol. x., p. 234.

fracture, which is now described as a condition of congenital rickets. In these cases there is an imperfectly ossified condition of the bones, which give way from the slightest violence, or it may be simply from the movements of the child in the uterus. In these cases the infant is born generally in a puny and ill-nourished condition, and with numerous fractures. Chaussier has recorded a case in which he found on dissection no fewer than one hundred and thirteen fractures of different bones in the same fœtus.

CHAPTER II.

CLASSIFICATION OF FRACTURES.

The varieties of fracture have to be considered first, as regards their *nature*, and secondly, as regards their *direction*.

Classification of Fractures as regards their Nature.

Fractures are always divided into two great classes: the *simple* or subcutaneous fracture, which does not communicate with the external air, and which may be said to correspond to a bruise of the soft parts; and the *compound* fracture, which is exposed to the air through a wound in the soft parts, and which may be said to correspond to a contused or lacerated wound which heals by second intention.

The wound which renders a fracture compound may be produced in several different ways, viz.: (1) By the broken end of the bone protruding through the skin, generally in an oblique fracture; (2) by the same

violence which produced the fracture, when it has been caused by direct violence; and (3) by subsequent sloughing of the integument over the fracture. This latter form of compound fracture is not nearly so dangerous to life as those where the wound is produced at the time of or immediately after the accident. For in these cases, before the fracture has become compound, the reparative processes taking place in the part have probably closed the torn vessels in the broken bone, and thus materially diminished the risk of septic absorption.

Besides this primary division, fractures are also divided according to the nature of the separation, into (1) single fractures; (2) multiple fractures; (3) comminuted fractures; (4) incomplete fractures; (5) perforated fractures. And to these must be added another group, which may comprise examples of any of the former ones, viz. fractures with complications.

1. **Single fracture.**—A single fracture of a bone may present several different varieties. It may be a simple single fracture, where the bone is broken at a single point, generally in an oblique or transverse direction. To this class belong the great majority of injuries of this kind which are met with. It may be *impacted;* that is to say, one fragment may be wedged into and fixed in the other. Or it may be *splintered*, a portion being chipped off, leaving the rest of the bone intact. This accident is generally caused by a sabre-cut, or a machinery accident, and therefore, though a single fracture, it is necessarily compound. Again, a thin shell of bone may be torn off in severe strains. A patient, slipping, falls to the ground with his leg doubled under him. This causes a great strain to be put on one of the ligaments of the ankle joint. The ligament, on account of its toughness and tenacity, is not ruptured, but is torn from the bone to which it is

attached, carrying with it the thin shell of bone into which its fibres are inserted. Hence these fractures have been termed by the late Mr. Callender, by whom they were first described, "*sprain fractures.*"* Lastly, among single fractures, we must include *separation of the epiphysis from the shaft of a bone.* Though, as I have already pointed out, these cases cannot be regarded as true examples of fracture, having regard to the etymology of the word, but rather as the separation of two bony surfaces from each other. It should be stated, however, that this view is not universally adopted, and some surgeons teach that the so-called separation of the epiphysis is not in reality a tearing of the epiphysial cartilage, but a true fracture occurring in the shaft of the bone just above this structure, so that the cartilage will be found encrusted with a thin layer of bone which has been separated from the shaft. Such was the view expressed by MM. Marjolin and Chassaignac in a discussion at the Soc. de Chir. de Paris in 1865, the former gentleman asserting that he believed "separations of the epiphyses to be extremely rare," and M. Chassaignac stating "that true separation of the epiphysis hardly ever occurs." † Mr. Holmes, with a view of testing this opinion, has examined all the specimens which he could find in the museums in London, and has arrived at the following conclusions : That fracture occurs not very rarely at or in the immediate neighbourhood of the epiphysial line, and that the line of fracture coincides in these cases partially with that of the epiphysial cartilage, but seldom completely ‡ (Fig. 1). The chief importance attaching to this form of injury is in connection with the ultimate changes which the injured cartilage may undergo, and the diminished

* St. Bart.'s Hosp. Reports, vol. vi., p. 51.
† *Gaz. des Hôp.*, 1865, Nos. 145—147.
‡ "Surgical Treatment of Children's Diseases," p. 238. 1868.

Fig. 1.—Separation of several Epiphyses in the Lower Limb.

growth and usefulness which may follow. Inflammation and permanent damage to the ossifying cartilage will probably result from its laceration, and deformity from loss of growth is likely to follow. Separation of the epiphysis appears to occur more frequently in the lower end of the femur than in any other situation. After this the lower end of the radius, the lower end of the tibia, and the extremities of the humerus, are the bones most frequently affected.

2. **Multiple fractures.** — Under the term multiple fracture are included two distinct and separate classes of cases : (1) where there is a fracture of two or more bones in the same individual ; (2) where there are two or more fractures in the same bone. The former accident (fracture of two or more bones in the same individual) is not an uncommon one, especially where two parallel bones, such as the tibia and fibula, or the radius and ulna, are subjected

The lower epiphysis of the femur, the lower epiphysis of the tibia, and both epiphyses of the fibula have been separated. It will be noticed that the line of separation in the lower end of the tibia passes partly through the epiphysial cartilage and partly through the bone. There is also a fracture of the lower third of the tibia. Taken from a boy, aged 18, who was leaping from a pier on to a steamer, when his foot caught in a rope and he was thrown into the water. (From a preparation in the museum of St. George's Hospital, series, i., 137.)

to the same violence; or, again, where two or more ribs are fractured in the same person, from any violence applied to the chest which compresses it. And, lastly, in severe accidents, such as a fall from a scaffold, many bones may be fractured in different parts of the body.

Two distinct and separate fractures in the same bone is not a common accident, though it occasionally occurs (Fig. 2). The manner in which the injury is produced is somewhat uncertain, but would appear to be caused by two different forces acting at the same time. They are to be distinguished from *comminuted* fracture where the bone is broken up into numerous fragments in consequence of extreme violence, and where there is therefore much greater injury to the soft parts, and consequently a greater amount of danger.

3. **Comminuted fractures** are where the injured part of the bone is broken up into numerous small fragments, or completely crushed, and sometimes even ground to powder. They are generally the result of direct violence,

Fig. 2. — Multiple Fracture of the Tibia.

There is a transverse fracture at the junction of the middle and lower third of the tibia, and an oblique fracture about the centre of the bone. Taken from a patient, who, in attempting to get out of a train in motion, was thrown to the ground. (From a preparation in the museum of St. George's Hospital.)

and often occur in the flat bones of the skull, as the result of blows from some heavy instrument. They also occur in the extremities when some body, as the wheel of a waggon, passes over them. They are therefore attended with great laceration and contusion of the soft parts, are for the most part compound, and, when occurring in the extremities, often require amputation. A less degree of the comminuted fracture sometimes occurs, where the bone at the seat of injury is broken up into several small fragments, which, if the fracture is compound, may be removed and the limb preserved, though with a certain amount of deformity and shortening. Should there be no wound they may necrose, from their vascular connections having been cut off, and be finally discharged.

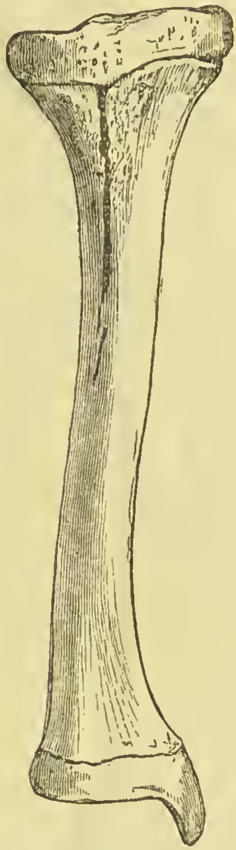

Fig. 3.—Longitudinal, incomplete Fracture of Tibia.

The tibia of a child, showing a longitudinal fissure, which traverses its shaft in the upper third. The fissure commences at the upper end of the diaphysis of the bone just below the cartilaginous epiphysis. There is no history of this preparation. (From the museum of St. George's Hospital, series i., 208)

4. The true **incomplete fracture** is often termed a "greenstick" fracture, but there is in addition to this another form of incomplete fracture, which usually occurs in the flat bones, especially the bones of the skull, and is termed a "fissure." Probably also some of the longitudinal

fractures of the shafts of the long bones ought also to be classed in this group of incomplete fractures. (*See* Fig. 3.)

The greenstick fracture is so called because the bone breaks in the same way as a piece of green wood when snapped across the knee. These fractures occur from indirect violence; that is to say, where the bone is compressed between two opposing forces. When this is done the bone first bends; when this bending has

Fig. 4.—Incomplete Fracture of the Right Clavicle.

The fracture has taken place through the middle third of the bone. The laminæ of the posterior surface are broken through, but those of the anterior surfaco are only partially broken and bent. Tho bone is longitudinally split through its middle third. The bone was removed from the body of a child aged 5 years. (From a preparation in the museum of St. George's Hospital, series i., 76.)

been carried to its extreme limits some of the fibres on the convex surface of the bend give way and the curve is increased. The continued application of the force now causes a longitudinal splitting of the bone, while the unbroken fibres on the concavity of the curve give more and more, and become displaced, though no actual solution of continuity takes place (Fig. 4).

The greenstick fracture usually occurs in children, while the bones are soft and contain a larger percentage of animal matter than in the adult. It very rarely occurs after the age of sixteen; but Smith records a case in a boy, aged eighteen, of incomplete fracture of the radius and ulna;* and Stimson another,

* *Dublin Quarterly Journal*, April, 1872; p. 351.

in which there was greenstick fracture of the same bones in a stout youth of eighteen.* The bones principally affected are those of the upper extremity; the clavicle and the bones of the fore-arm being the ones which most frequently suffer.

There is a form of fracture which occurs in the skulls of children which presents another example of the greenstick fracture. The child, generally after a fall on the head, presents a slight depression of the skull, not attended by any brain symptoms. After a time the bone gradually becomes pressed out. By some this has been believed to be due to simple bending of the bones.

5. **Perforated fractures.**—This class of fracture generally occurs in military surgery from gun-shot wounds, but may occur from the perforation of a bone by any pointed instrument. They are, therefore, of necessity always compound. The bone is perforated, but its continuity is not interrupted. They may be of two kinds, complete and incomplete. In the former case, the body which produces the injury passes completely through the bone; in the latter it only penetrates a portion of its substance.

6. **Complicated fractures.**—A fracture may be complicated with other injury, which is often of more importance than the mere fracture itself. (1) It may be complicated by an injury to some internal viscus, from the broken portion of bone being displaced and driven by the violence of the accident into some neighbouring organ. The danger here depends not on the fracture, but on its complication with internal injury. (2) A fracture may be complicated with injury to some important blood-vessel or nerve; for instance, the anterior tibial artery, being in close contact with the bone, is frequently lacerated by the broken end of the tibia in fracture of this bone. The internal jugular vein has been known to be torn in

* On "Fractures," p. 41. 1883.

cases of fracture of the clavicle, and death has occurred from hæmorrhage. The brachial plexus may be lacerated in fracture of the same bone, as in the well-known case of the late Sir Robert Peel, or the musculo-spiral nerve may be damaged in fracture of the shaft of the humerus. (3) A fracture may be complicated by injury to some neighbouring joint; that is to say, the fracture extends into the joint, or is situated entirely within the articulation. Some fractures are always complicated in this way, as, for instance, intracapsular fracture of the neck of the thigh bone, the T-shaped fracture which occurs at the lower end of the humerus and femur, most cases of transverse fracture of the patella, and many others. In these cases the encrusting cartilage is torn, and the synovial fluid, which is often secreted in considerable quantities in consequence of the injury done to the synovial membrane, finds its way between the fractured surfaces. To this is attributed, by some, the tendency to fibrous union which obtains in these cases. Where a fracture extends into a joint there is always a risk of impaired mobility from fibrous adhesions, the result of inflammation taking place in a joint. (4) A fracture may be complicated with dislocation. Thus, fractures of the olecranon and coronoid processes of the ulna are sometimes complicated with dislocation forwards or backwards at the elbow joint. The so-called "Pott's fracture" is a fracture complicated with dislocation. A more serious variety of the same injury occurs occasionally where fracture of the neck of the humerus is met with, together with dislocation of the head of the bone.

Classification of Fractures as regards their Direction.

The direction which a fracture assumes is very various, and is of importance in regard to the cause

which gave rise to the fracture. They may be arranged under three different heads, to which, however, there are certain modifications; viz. the oblique, the transverse, and the longitudinal, named in the order of their frequency.

It must be borne in mind, however, that these varieties are not always exactly defined, but that the one form may merge more or less into another; thus, the transverse fracture on the one hand and the longitudinal on the other usually have a certain amount of obliquity, and so merge into the oblique form of injury; so that in speaking of fracture of one or the other kind we merely infer that it has a more or less transverse, oblique, or longitudinal direction, as the case may be.

Oblique fractures are the most common form in fractures of the extremities, and usually occur from indirect violence. The amount of obliquity may vary very much; on the one hand, oblique fractures may be only one degree removed from transverse fractures, while on the other they may be almost longitudinal, running more than half the length of the shaft of the bone. They partake somewhat of the character of the greenstick fracture, and are produced very much in the same way. That is to say, the bone is compressed by two opposing forces; it bends; a few fibres give way on the convex surface of the curve, and thus allow a further bending to take place. A fresh disruption of fibres now occurs at a higher level than the former, because, of the two forces applied to the bone, the one is an active or moving force, the other a stationary one, and a further bending occurs; this process being continued, a gradual solution of continuity takes place in a direction upwards and inwards; that is to say, *upwards* towards the moving force which produces the fracture, and *inwards* towards the concavity of the curve produced by the original bending of the

bone, and thus an oblique fracture is produced. The oblique fracture is more dangerous than the transverse, and the more oblique the greater the danger, since, owing to the obliquity of the fracture causing the broken ends to be pointed, there is greater probability of laceration of the soft parts, and even perforation of the skin, and the production of a compound fracture. There is also in these cases a greater difficulty in maintaining the fractured surfaces in apposition, and, of course, a larger surface for repair. A variety of the oblique fracture is sometimes described as the *serrated* fracture. As its name implies, it is a fracture where the opposite surfaces present a serrated or dentated outline, so that they may interlock, and thus present an impediment to reduction if displacement has taken place.

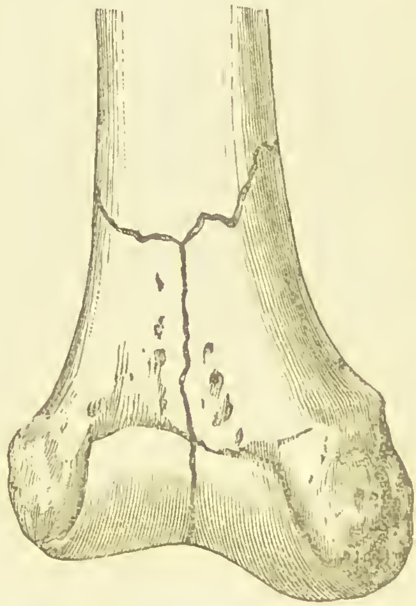

Fig. 5.—A T-shaped Fracture of the lower end of the Femur.

There is an oblique fracture of the lower fourth of the shaft of the femur, the direction of which is from above and behind downwards and forwards. The lower fragment, including the condyles, is divided into two parts by a perpendicular fracture, which joins the oblique one. Taken from the body of a young woman who fractured her thigh by a fall from a cart. (From the museum of St. George's Hospital, series i., 133.)

The **transverse** fracture is usually produced either by direct violence or by muscular action. There is often a certain slight obliquity of the fracture, cases where the line of disunion is absolutely at right angles to the bone being extremely rare; they do, however, occasionally occur. (*See* Fig. 9.)

Examples of transverse fracture from muscular action are constantly seen in the patella, and less commonly in the olecranon. Separation of the epiphysis of a long bone as occurring in children may also be regarded as a form of transverse fracture.

The **longitudinal fracture.** — The exact mechanism by which this fracture is produced in long bones is not definitely known in all cases. No doubt in most it is produced by direct violence, and especially from gun-shot injuries; but in others it would appear to be the result of extreme violence exerted upon one end of a long bone in the direction of its long axis, while the other end of the bone is fixed.

A combination of the two preceding fractures is not uncommonly met with, especially in the lower end of the humerus and femur, constituting the T-shaped fracture; that is to say, a transverse fracture across the shaft of the bone above the condyles, and a longitudinal fracture running down from the transverse one into the joint between the condyles (Fig. 5).

CHAPTER III.

SYMPTOMS AND DIAGNOSIS OF FRACTURES.

THE diagnosis of a fracture is sometimes remarkably easy; the symptoms are so unequivocal that the nature of the lesion may be ascertained at a glance; in other cases it is just as difficult, and sometimes, indeed, impossible, and we can only, after the most careful examination and the most rigid scrutiny, arrive at the conclusion that there is probably a fracture, without being able to come to a definite opinion on the point.

The symptoms by which we diagnose a fracture are very numerous, and may be enumerated as follows:

(1) The history of the accident; (2) pain; (3) deformity; (4) increased mobility in the continuity of the bone; (5) inability to move the limb; (6) inability on the part of the fragments to maintain their position when reduced; (7) crepitus; (8) ecchymosis.

Some of these symptoms are quite pathognomonic of the injury when they exist; but, nevertheless, a fracture may have taken place without their being present. Other of the symptoms are much more equivocal, but still are important, especially in doubtful cases, in substantiating the diagnosis.

1. The **history of the accident.**—The manner in which the accident occurred, and the nature and force of the injury, should always be inquired into, and may assist in giving some idea of the character of the lesion. The narration of the history will often, too, elicit one important fact, which, when it is present, is highly characteristic; and that is, that the patient is himself conscious that a bone is broken from having heard a distinct and audible snap at the moment of the accident. This is by no means constantly complained of, since the patient at the time of the accident is too much agitated to be aware of it; but that most bones do give way with an audible crack is more than probable, especially because the cases in which the patient is aware of it are those in which he is not agitated at the time of the accident, as, for instance, in spontaneous fracture.

2. **Pain** is, of course, a symptom of fracture, as of every other lesion, and it would scarcely seem necessary to allude to it as one of the diagnostic symptoms of the injury, except to point out that its presence is useful in drawing our attention to the

exact seat of injury, and its character, *fixed* and *abiding*, is often of importance in distinguishing between a fracture and a contusion, where the pain is more diffused and less persistent.

3. **Deformity**, or alteration in the shape of the part, may be due to three causes: (1) swelling; (2) displacement of the fragments; (3) separation of the fragments. The swelling which attends a fracture is due, in a recent case, to extravasation of blood; later on it may be produced by other causes, the effusion of inflammatory products or œdema. The blood comes from the torn vessels in the broken ends of the bone, and also from any vessels which have been injured in the surrounding parts. It is sometimes poured out in large quantities, producing great swelling, and thus interfering with the diagnosis by obscuring other signs.

Deformity due to displacement of the broken portions of bone is one of the most valuable signs of fracture. Sometimes, in fact, to the practised eye, the deformity produced by a fracture is sufficient to establish the diagnosis. The principal causes of displacement of the broken ends of a bone are three: *First*, the same violence which produces the fracture may cause also the displacement; as, for instance, in a depressed fracture of the skull, the blow which produced the fracture, by its continued action drives the bone inwards, and so produces the displacement. *Secondly*, the weight of the limb or body may produce displacement of the broken ends of the bone; as in fracture of the clavicle, the outer fragment is drawn downwards by the weight of the arm. *Thirdly*, muscular contraction is undoubtedly the most active cause of displacement. The muscles by their contraction, which may be either tonic or spasmodic, approximate their points of attachment, owing to the support afforded by the bone having been

removed, and thus produce the displacement of the fragments and deformity of the limb. In the extremities the displacement is generally produced by the lower fragment being drawn upwards, and therefore the form of deformity is shortening; other varieties may, however, occur. To these three principal causes of displacement may be added a fourth, where it is produced by some rough or injudicious handling on the part of the attendant, or to the violence of the patient himself during delirium.

The direction in which the displacement takes place depends upon the direction and force of the impulse which caused the fracture, the position of the limb and the muscular contraction which no longer acts upon the whole bone, but on a part of it; it may be *angular,* where the axis of the bone is altered at the seat of fracture, so that the fragments form an angle; *lateral*, where one fragment is displaced to one side or the other; *longitudinal*, where one broken end overlaps the other; and *rotatory*, where the lower fragment is twisted on its own axis, so as to produce a rotation of the limb below the seat of fracture.

The deformity due to the separation of the fragments is seen only in transverse fractures, and especially in fractures of the patella, os calcis, and olecranon, and is generally due to muscular action. In fractures of the os calcis, for instance, when arising from muscular action, the posterior part of the bone may be felt some inches above the heel, having been drawn upwards by the muscles of the calf.

4. **Increased mobility in the continuity of the bone** is an important symptom of fracture if its presence can be undoubtedly ascertained; but, unless care be taken, error is likely to creep in. On the one hand, there may be a fracture and no preternatural mobility, as in cases where the fracture is impacted;

in some instances of serrated fracture, and in incomplete or greenstick fracture. And, on the other hand, where a fracture takes place in the neighbourhood of a joint, the normal movements of the articulation may be mistaken for the preternatural mobility of a fracture. Again, the elasticity of some bones, especially the ribs, may convey to the surgeon an impression of increased mobility, and may be attributed to fracture unless care be exercised. When, however, the presence of increased mobility in the continuity of a bone can be undoubtedly ascertained, it becomes an unequivocal sign of a broken bone.

5. **Inability to move the limb** is so constant a symptom of all injuries on account of the pain produced by so doing, that it scarcely seems necessary to allude to it as a special symptom of fracture; but in fracture this disability arises from a special cause; from the solution of continuity of the bony lever on which the muscles act. In impacted and greenstick fractures, therefore, this symptom, as far as regards this cause, cannot be said to exist.

6. **Inability on the part of the fragments to maintain their position when reduced.**—This is an important symptom of fracture in regard to its diagnosis from another form of injury, dislocation.

It will be noted in the sequel, in speaking of the diagnosis of fracture, that the main injury for which it is liable to be mistaken is dislocation. And in this symptom of the inability on the part of the fragments to maintain their proper position in fracture after reduction, unless some means be taken to maintain them in their proper position, we have an important diagnostic sign by which we can distinguish it from a case of dislocation, where, as a rule, there is little tendency for the displacement to recur after reduction, except in one or two exceptional cases.

7. **Crepitus.**—This, perhaps, of all symptoms, is the one on which most stress is laid in the diagnosis of fracture; but here also error may creep in unless caution be employed. For, in the first place, sensations other than those produced by rubbing of two bony surfaces together may be mistaken for crepitus; and, secondly, a fracture may exist, and still this symptom be absent. The peculiar sensation produced by moving over one another the two surfaces of a synovial membrane, when it is roughened by inflammation, or of a bursa, or sheath of a tendon in the same condition, is not unlikely to be mistaken for crepitus, especially in the inexperienced hand.

The sensation, however, to the practised touch is very different, being softer, more subdued, and more prolonged, and a mistake ought not to occur. It is said also that the peculiar crackling sensation produced by air bubbling through the cellular tissue in cases of emphysema may be mistaken for crepitus.

On the other hand, crepitus is absent in many cases of fracture. In the impacted fracture, and, as a rule, in the incomplete fracture, crepitus is not to be felt. So, again, when the broken ends cannot be brought into apposition, either from over-much separation or from over-riding, crepitus cannot, of course, be elicited. In instances where the one fragment cannot be made to glide over the other, as in serrated fractures, crepitus is also absent. Foreign bodies between the ends of the broken bones, as a clot of blood or a piece of muscle, prevent crepitus. Lastly, the ends of the bones may be softened by old age, as in the neck of the thigh bone, or, after some time, may be coated with a layer of plastic material from inflammation, so as to render the sensation of crepitus very obscure, or altogether absent.

8. **Ecchymosis.**—Allusion has already been made to the subject of extravasations of blood as a

symptom of fracture; but it seems desirable to allude to it again under a special heading, since it is almost the only symptom which we possess as a means of diagnosis in certain cases of fracture. Thus, in some fractures of the base of the skull, extravasation of blood, and consequent discoloration, is the main symptom on which we rely in diagnosing these injuries.

Again, in fracture of the lower end of the fibula there are often none of the ordinary signs of fracture present, no displacement, no crepitus; possibly only a fixed pain, which might be mistaken for a contusion or a sprain, which may co-exist. The appearance, in the course of a few days, of a linear ecchymosis along the line of fracture, will establish at once the diagnosis.

By a careful attention to the above-mentioned symptoms, the diagnosis of fracture can generally be made. There are two forms of injury with which it may be mistaken, viz. dislocation and severe contusion.

From **dislocation** there is seldom much difficulty. In addition to the symptom to which allusion has already been made, that a dislocated bone, when reduced, remains in its place, while the deformity of a fracture at once returns, when the extension employed for its reduction has been relaxed; there is an absence of crepitus, unless the dislocation be complicated with fracture and preternatural immobility, instead of the increased mobility which is so characteristic a symptom of fracture.

From **contusion** it is not always possible to come to a correct diagnosis at first. If the extravasation is great, the natural contour of the parts is so altered as to mask any deformity which may exist, and the crepitus transmitted through a great mass of blood may be obscured and lost. Under these circumstances a guarded opinion should be given, and the case treated as one of fracture, until the subsidence of the

swelling allows us to examine the part with more prospect of clearing up our doubts. This is especially essential if fixed pain in one particular part of the bone is complained of.

It remains now to say a word or two on the symptoms of some special forms of fracture, in so far as they differ from the signs of ordinary fracture.

Impacted fractures.—The presence of impaction often renders the diagnosis of fracture very difficult. In consequence of the one fragment being driven into and fixed in the other, two of the most prominent signs of fracture are of necessity absent, that is to say, crepitus and increased mobility in the continuity of the bone. The presence also of a considerable amount of swelling may mask any displacement which may exist, and will add to the difficulties.

The surgeon must be guided in forming an opinion, first of all, by the history of the accident, being such as would not only produce a fracture, but also, from the direction of the violence, would have a tendency to impact or force the one fragment into the other; secondly, by the seat of the injury, *e.g.* if it occurs at the extremity of a long bone, where the part impacted consists of loose cancellous tissue, while the impacting portion is compact, solid bony tissue; and, thirdly, by the deformity or distortion present whether it is characteristic of the particular fracture.

Incomplete fractures.—The signs which indicate the presence of a *fissure* of a bone are not sufficiently marked to render a diagnosis by any means certain. The presence of fixed pain in one particular spot in a bone after the receipt of a severe injury, probably from direct violence and the appearance of a linear ecchymosis, after the lapse of a few days would justify us in assuming that a fissure of the bone had taken place, though it would not entitle us definitely to state that such was undoubtedly the case.

In **greenstick** fracture the diagnosis is less difficult, since there is the presence of deformity, which, when occurring in a child as the result of indirect violence, may be looked upon as sufficient evidence on which to base a diagnosis.

In subcutaneous bones the presence of a lump at the seat of injury may also be observed, and in some cases crepitus may be evolved upon attempting to overcome the deformity.

Separation of the epiphyses.—These injuries necessarily occur in the young, before the age of eighteen or twenty, and for the most part much earlier. The first point, therefore, in the diagnosis, is the age of the patient; secondly, the position of the injury at the extremity of a long bone, or in a position corresponding to an epiphysis; thirdly, the nature of the crepitus, which in the true form of the injury is of a softer and less marked character. It must be borne in mind, however, that in the majority of these so-called cases of separation of the epiphyses there is a certain amount of disunion of bony material, as has been stated above, and that in these cases the crepitus will be well marked and rough, as in ordinary fracture; lastly, the projecting fragments, if they can be perceived, will present a more rounded outline than the sharp margin of a broken bone. The distinction, however, between a transverse fracture of the shaft of a long bone in the neighbourhood of a joint and the separation of the epiphysis is not always possible, and, fortunately, as regards the treatment, an error in judgment is a matter which will not materially interfere with the welfare of the patient. Nevertheless, the subject is of importance as regards the prognosis, since injury to the epiphysial cartilage is liable to be followed by diminished growth and impaired usefulness of the limb.

CHAPTER IV.

THE UNION OF FRACTURES.

The manner in which fractured bones unite is still, to some extent, an open question. This is partly due to the difficulties which exist in obtaining opportunities of examining recent fractures, during the process of union, in the human subject; partly to the fact that fractures in the lower animals do not unite in a manner similar in all respects to those in man; and, lastly, because union takes place in a different manner in different fractures; that is to say, the process of union in a simple fracture differs from that in a compound fracture, and, again, in the former class, simple fractures unite in different ways under different circumstances.

Union of Simple Fractures.

It will be convenient, in order to give a comprehensive, and it is to be hoped a clear, view of what is known on the subject, to consider the union of simple fractures under three different heads:

(1) The union of a simple transverse fracture, where there is no displacement, and where there has been but little laceration of surrounding parts.

(2) The union of a more or less oblique fracture, with a greater or less amount of displacement, and with injury to surrounding parts.

(3) Union of a fracture in which the ends of the bone are not kept strictly in apposition.

First.—Union of a simple transverse fracture, without displacement and with little injury to surrounding parts. For the sake of analogy, this may be compared to a clean, incised wound, in which the

edges are brought into immediate apposition without the intervention of any foreign body. Such a wound usually unites by "primary adhesion," that is, by adhesive inflammation. The same thing occurs in bones. If the fracture is transverse or only slightly oblique, and is unaccompanied by displacement, the amount of injury to the tissues around the fracture is slight, and consequently the extravasation of blood inconsiderable in amount.

The first change consists in a limited amount of inflammation appearing in the bone ends and in the periosteum surrounding them. The latter becomes vascular and thickened, and the Haversian canals of the bone dilated and hypervascular and the bone tissue softened. As a result of this hyperæmia, an inflammatory new growth is poured out between the ends of the fractured bone, and also probably to a slight extent in the deeper layers of the periosteum next the bone. This forms a thin pulpy layer, which, on microscopic examination, presents small roundish cells, similar to white blood corpuscles, together with others presenting the varied form of embryonic medulla. This material next becomes infiltrated with calcareous salts, and finally undergoes a slow process of ossification. This may occur either directly from the immediate ossification of the new cells of the inflammatory material, or after the new growth has passed through an intermediate cartilaginous stage. Probably in these cases of fracture without displacement the intermediate cartilage is rarely or never formed, though there is even here some appearance of the formation of this material, since in some sections the cells may be noticed to be encapsuled and the intercellular substance present a hyaline appearance.

Secondly, we have to consider the union of a more or less oblique fracture with a greater or less amount of displacement and with injury to surrounding parts.

In consequence of this injury to the tissues in the neighbourhood of the fracture, the amount of blood poured out is very much greater than in the former instance. If a recent fracture be examined, the whole of the tissues in the neighbourhood will be found to be infiltrated with extravasated blood. This blood is gradually absorbed during the first ten or twelve days which succeed a fracture, either altogether, or only a very small portion remaining. Whether this remaining portion becomes converted into callus or not is doubtful. Whether, in fact, the extravasated blood is simply to be regarded as a foreign substance which must be got rid of before union can be accomplished, or whether, as Mr. Greig Smith believes, the clot actually becomes organised and forms an important element in the repair of fracture, is, at present, uncertain.* It would be foreign to the scope of this work to enter into a discussion on this question, further than to remark that the opinions of Mr. Greig Smith appear to require further confirmation before they can be adopted as definitive.

After the effused blood has been absorbed, the changes which take place around the displaced fractured ends of the bone are the same in their main features as the union of the transverse fracture without displacement. They differ principally in the source from which the new bony material is derived; for whereas, in the former case, it was found to proceed mainly from the fractured ends of the bone, here it is derived from the tissues outside the bone, viz. the periosteum covering it and the structures external to the periosteum, as ligament and tendon, intermuscular connective tissue, and sheaths of vessels and nerves. But it is to be noted that in both instances the inflammatory new growth is derived from the same kind of structure, viz. connective tissue. In the one instance

* *Journal of Anatomy and Physiology*, vol. xvi., part 2, p. 153.

from the connective tissue surrounding the blood-vessels of the Haversian canals in the immediate neighbourhood of the fracture, in the other from the connective tissue surrounding the bone, the periosteum, and the tissues in immediate relation with it. This connective tissue becomes the seat of inflammatory changes; a new material is formed, consisting of small rounded cells, which infiltrate the tissues mentioned above, being placed between those parts of the broken bone whose surfaces are opposed, so that its extent increases in direct proportion to the amount of displacement. This condition is well shewn in the preparation from which the accompanying figure was taken, (Fig. 6). It will be seen that there is a large mass of intermediate callus, or new bone growth, thrown out between the two displaced fractured ends, where it is required in order to cement the bones together, but throughout the rest of the circumference of the upper broken end there has been no deposition of new material. This inflammatory exudation has been poured out from the connective tissue in the neighbourhood, partly from the periosteum and partly from

Fig. 6.—Union of Fractured Thigh by Interposed Callus.

The fracture has united with very great deformity. The upper fragment has been displaced forwards and a little outwards, and the lower fragment has been drawn upwards and backwards. Between the two a large amount of bony callus has formed, firmly uniting them together. (From a preparation in the museum of St. George's Hospital, series ii., 100.)

the soft parts around the fracture. The subsequent changes which take place in this new formation are identical with those which occurred in the new growth situated between the ends of the bone in the transverse fracture without displacement. It must be borne in mind that this new growth consists of an infiltration of the connective tissue with cells, which consist, in a great measure, of leucocytes. The connective tissue wastes and softens and shows a tendency to become converted into its earlier embryonic condition. It then undergoes a process of calcification and becomes converted into bone, either directly, or sometimes, especially in children, through the intervention of a cartilaginous stage. The occurrence of the intermediate cartilaginous stage, or, perhaps, more strictly speaking, the formation of a material resembling cartilage, is more frequent in this form of union of fracture than the former.

In such an extreme example of displacement as the one figured above (Fig. 6), where the fractured ends overlap one another, the broken extremities are nowhere in apposition; nevertheless a similar process takes place here as in the case of the transverse fracture without displacement. That is to say, a limited amount of ostitis takes place. The Haversian canals enlarge, the cellular tissue which they contain becomes infiltrated with cells, and an inflammatory new growth is poured out over the fractured extremity of the bone. This undergoes calcification and ossification, and becomes converted into a thin shell or scale of bone which closes in the medullary canal. This condition is well shown in the preparation from which the accompanying figure is taken (Fig. 7), where the extremities of the medullary canal, ten weeks after the accident, are seen to be closed with a thin layer of very porous and friable bone.

Thirdly.—Union of fracture in which the ends of the

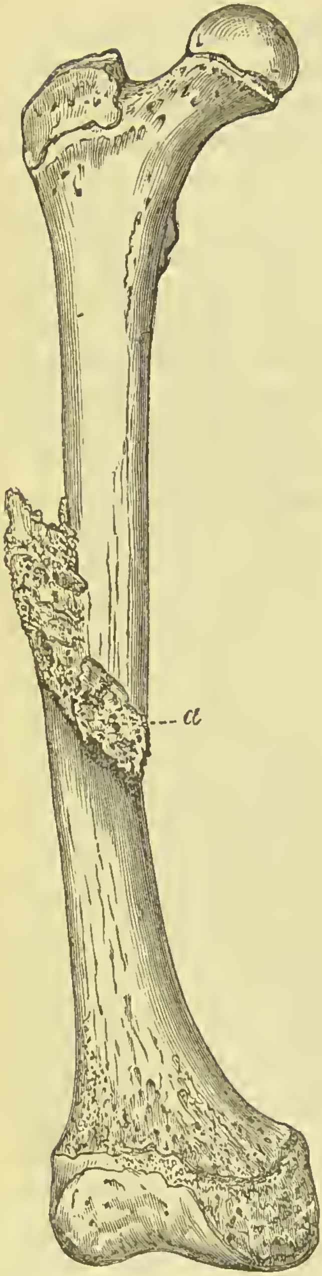

Fig. 7. — Femur fractured through the Centre of the Shaft.

bone are not kept strictly in apposition. When the fractured ends of a bone are not kept strictly in apposition a mode of union takes place which is described by Dupuytren as the ordinary way in which all fractures unite. He declares that "nature never accomplishes the immediate union of a fracture save by the formation of two successive deposits of callus," and his description was formerly accepted without hesitation and universally adopted. The source of error arose, no doubt, from the fact that Dupuytren derived all his information on this subject from experiments on the lower animals, in whom, from the impossibility that there is of keeping the ends of the fractured bone in perfect apposition, union takes place always, or almost always, by this double method. The process may be briefly described as follows. After the extravasated blood, which is poured out as the result

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The portions of bone overlap each other to the extent of about three inches, the lower fragment being directed outwards and backwards, and united to the upper fragment, in this position, by a bridge of bone. The medullary canal in each fragment is closed by a thin scale of bone (*a*). (From a preparation in the museum of St. George's Hospital, series i., 167.)

of the injury, has been almost, if not completely, absorbed, inflammation is set up in the medullary membrane, in the bone itself, in the periosteum around the fractured bone, and in the neighbouring tissues external to the periosteum. This is attended by the effusion of an inflammatory exudation which takes place (α) in the medullary canal, forming a plug and sometimes named "interior callus"; (β) between the ends of the bone, as in the ordinary transverse fracture without displacement, called "intermediate callus"; and (γ) around the ends of the bone, either in the substance of, or external to, the periosteum, where it forms a fusiform mass, of greater or less extent, according to the exigencies of the case, which completely surrounds and encloses the fractured ends of the bone, and is hence named "ensheathing callus" (Fig. 8). The interior callus and ensheathing callus are named together "provisional," since they are only temporary, thrown out rapidly in order to support the fracture and maintain the broken ends in apposition,

Fig. 8.—Section of a Femur, showing Union of Fracture of the Shaft, in a child.

In the fresh state the fractured ends were surrounded with a red, fine-grained callus and slightly separated from each other by a line of transparent soft tissue which extended from the medulla of the bone to a small cavity in the callus. Under the microscope islands of cartilage were discovered in the callus. Taken from the body of a child who died on the 37th day after the accident from laryngitis. (From a preparation in the museum of St. George's Hospital, series i., 145, *b b*.)

like a splint; while the intermediate callus is termed "definitive," and is more slowly but permanently soldering the ends of the bone together; as soon as this is accomplished the provisional callus is removed by absorption, being no longer required. The process of ossification is identically the same in the two forms, the only difference being the greater rapidity with which it takes place in the provisional than in the definitive callus. The inflammatory exudation is converted into bone either directly or through the intervention of a cartilaginous stage, this latter occurring frequently in children and in the lower animals. As soon as the process is completed in the definitive callus, the provisional callus, being no longer required to maintain the parts in apposition, is absorbed. *Altogether*, if the bones have been placed in accurate apposition so that one fractured end exactly coincides with the other; in *part*, if the broken bone has not been maintained in proper position, since a small portion of it remains, filling in any angles and rounding off any prominences which may exist. The interior callus or plug of bone within the medullary canal also becomes absorbed and the channel re-established. So that, in cases where no displacement of the fragments has been allowed to remain, it is impossible, upon examination of the bone after death, when the process has been completed for some time, to point out the situation of the fracture.

Occasionally it happens that no formation of intermediate or definitive callus takes place. The provisional callus then remains permanently, and is the only means by which the broken bone is joined and the ends maintained in apposition.

Such is the process of repair of fracture as it takes place in the lower animals, and in man when the ends of the bones are not maintained in strict apposition. Accordingly we find union taking place

in this manner in certain bones which cannot be maintained in an immovable position, and in which the fractured ends cannot be kept strictly quiet. In the clavicle and the ribs, bones which are subjected to constant motion in the movements of respiration; in young children, where it is often impossible to maintain at all times perfect apposition of the fragments; in patients suffering from delirium, and, in fact, in any case where from any cause whatever movement of the broken ends is permitted, then the deposition of provisional callus is to be expected. Provisional callus, therefore, is developed in relation to the necessities of the individual cases, and has "no final purpose, but is the unavoidable result of certain abnormal conditions. It is just as much the necessary result of natural laws as is definitive callus." *

Fig. 9.—Necrosis after Compound Fracture of the Tibia.

There is a transverse fracture near the middle of the tibia. Portions of the fractured ends have died and are in a process of separation. Immediately above and below the necrosed pieces new bone has been deposited for some distance on the surfaces of the tibia. From a patient whose leg was amputated for diffuse cellular inflammation after compound fracture. (From a preparation in the museum of St. George's Hospital, series i., 176.)

UNION OF COMPOUND FRACTURES.

The process of union in a compound fracture is identical with "union by granulation" in an ordinary

* Hamilton on "Fractures and Dislocations," p. 43. 1871.

wound. Nevertheless, all fractures which once were compound do not unite in this way. A compound fracture may be converted into a simple fracture by the healing of the external wound, and the union in these cases follows the course above described as pertaining to simple fracture. The cases where this occurs are generally those where there is a small wound produced by the fractured end of the bone protruding through the skin, and where there is comparatively little laceration of the soft parts.

In a compound fracture where there is but little contusion of the broken ends or splintering of the bone, and where the periosteum has not been extensively injured, union takes place by granulations forming over the fractured surfaces and becoming converted into bone, and thus constituting the bond of union. When, on the other hand, the ends of the broken bone have been so injured by the violence of the injury that their vitality is destroyed; or where the periosteum surrounding them has been so crushed or torn that the circulation through it is arrested, the ends of the bone die and have first to be separated from the living bone before union can take place (Fig. 9). This is effected by a process identical with that of separation of sloughs in soft parts, and after its completion union takes place by the conversion of the granulations into bone.

CHAPTER V.

TREATMENT OF FRACTURES.

THE treatment of fractures has to be considered under three different heads. First, the reduction of the fragments to their normal position, popularly termed "setting" the fracture; secondly, the means by

which the fragments, being reduced, are maintained in their proper position and a return of the displacement prevented until consolidation has been effected. This is termed "putting up" the fracture; and, thirdly, the general and constitutional treatment of the patient.

1. **The reduction of the fracture.**—The time at which this should be done merits consideration. There can be little doubt that in the majority of cases the sooner it is effected the better; for, in the first place, reduction can be more easily accomplished immediately after the receipt of a fracture than if it is delayed for some days, during which time the muscles become rigid and shortened and their fibres matted together by inflammatory effusion. They thus offer a very serious impediment to reduction, requiring the employment of great force, which may sometimes be attended with injury to other structures and must at all times be injurious and prejudicial to the patient. Again, if the patient is seen directly after the accident, he is in all probability suffering more or less from shock, and his muscles are flabby and yielding. This is the time to seize for the reduction of the fragments. After reaction has come on, the muscles are thrown into a state of contraction; sometimes, when irritated by a sharp fragment, into *violent* contraction, and a much greater force is therefore required to overcome them. If a fracture is left unreduced, a sharp fragment may at any time perforate the skin, or a displaced fragment by pressure may cause sloughing, and thus render a simple fracture compound. Or the displaced bone may irritate and lacerate muscles and nerves, inducing violent and painful spasm, and often undue inflammatory action. Finally, the early reduction of a fracture allays the anxieties of the patient. There is in his mind, and that of his friends, a

vague fear as long as the fragments are out of place, and a sense of relief is always experienced by them when they are informed that the limb is "set." Moreover, at the time of the accident the patient will willingly submit to any measure which may be deemed necessary, while often after the lapse of a few days he will resent any interference with his limb, and will refuse to permit it to be disturbed.

There are, however, certain cases in which an exception must be made to the general rule of reducing a fracture as soon as possible after its receipt. If there is great swelling and ecchymosis, and the whole limb infiltrated with blood, and the exact position and nature of the fracture scarcely to be made out, it is perhaps the wiser course not to make any attempt to bring the fractured ends of the bone into exact apposition. At all events any attempt should be of the gentlest kind. The limb should be placed as nearly as possible in its proper position and supported by means of sand-bags or some soft splint, as a junk, until the swelling has somewhat subsided, when reduction may be effected without so much risk to the patient. Care must be taken in these cases not to apply any apparatus which will obstruct the circulation, or else gangrene will be the inevitable result. For the same reason, the application of ice or irrigation is to be avoided; they lessen the vitality of the part, and may be the means of determining the gangrene or sloughing, which may be impending from the laceration and injury done to the tissues.

Sometimes also in cases of excessive spasm it is better to defer the attempt to effect reduction. Formerly the occurrence of spasms presented an insurmountable difficulty to the reduction of a displaced bone, and the division of tendons and muscles was resorted to, in order to overcome its influence, but since the introduction of anæsthetics,

there are few cases in which the deformity cannot be overcome and reduction effected. In cases of severe spasm any attempt to reduce the displacement by force without an anæsthetic will be of no avail, and in former days, even after the division of tendons, the surgeon had often to be content with a very imperfect result.

In all cases where there is any difficulty in effecting reduction, either from spasm or otherwise, the exhibition of an anæsthetic is indicated. But under ordinary circumstances, unless the patient is very nervous, it is better to avoid giving chloroform or ether. The patient, suffering from shock, is not in the best possible condition for taking an anæsthetic, especially chloroform, and unless plenty of assistance is available, he may during his struggles, while semi-unconscious, do himself considerable harm. And even with a number of assistants to prevent it, the convulsive twitchings of the muscles may force the end of the bone through the skin. In the majority of cases it will be found that the broken ends of the bone may be replaced, if gentleness and caution are exercised, without any difficulty, and without causing the patient much, if any, pain.

The principal factor in the displacement of a fracture is muscular contraction; and it is to this force that we must especially pay attention in reducing it. We may overcome this muscular influence in two ways: either by placing the limb in such a position that the muscles which are the cause of the displacement shall be relaxed, when the broken ends of the bone will naturally fall into their places, if no other cause of displacement be also present; and, secondly, we may combat the muscular contraction by a superior force, by applying extension to the muscles until they yield. In doing this it must be borne in mind that a steady and continuous strain on the

muscles is more likely to effect the object in view than any sudden and violently applied force. The muscles will resent any sudden force, but will yield, after a time, from fatigue, to steady and well-directed traction.

It is not often that we are able to set a fracture by simply relaxing the muscles, since it generally happens that the position required to relax the muscles acting on one fragment causes stretching of the muscles acting on the other, and therefore does not overcome the displacement. Certainly if there be any shortening this plan will be of no avail; it can only be applied where there is slight angular or rotatory displacement, or, perhaps, separation of the fragments. The means, therefore, to which the surgeon will principally have to trust in the adjustment of his fracture is extension. In making this extension the upper end of the bone should, if possible, be firmly and steadily grasped by an assistant; *counter-extension.* This, however, cannot always be done, as, for instance, in fracture near a joint, when the limb must be firmly held at or above the articulation; in fact, in the most convenient position for obtaining an effective grip. The surgeon, holding the bone below the seat of fracture, makes steady and continuous traction upon it, at the same time swaying it from side to side, or gently rotating it until the deformity is overcome. Occasionally it will be found advantageous to require a second assistant to make extension, so that the surgeon's hands may be free to seize the bone at the seat of fracture, and by gentle pressure push the fragments into position.

The following rules should be borne in mind in making extension: (1) it should be steady and con tinuous and free from all jerks and violent movement; (2) it should be made in the direction of the axis of the bone; (3) if it be possible, the

fractured bone should be grasped at either extremity and extension made without implicating neighbouring bones; (4) the principal muscles acting on the fragments should be relaxed; (5) the extension should not be carried to such an extent as to do injury to the neighbouring tissues, even though the deformity be not overcome. The amount of extension proper must be left to the discretion of the surgeon in each individual case, varying with the degree of swelling, inflammation, or muscular spasm which may exist. In some cases it will be found impossible to restore the full length of the bone, and the wiser course to pursue is not to make too prolonged efforts to the detriment of the patient, but after as much of the shortening as is possible has been overcome, to place the bones as nearly as may be in their proper position, and carefully watch the case so as to seize the earliest opportunity to complete the adjustment. Occasionally it will be found that the efforts to obtain complete extension are rendered futile by the contraction of one muscle. Its tendon may then with propriety be divided. This is especially the case with fractures at the lower third of the leg, where the violent contraction of the large muscles of the calf renders any attempt to reduce the fracture unavailing. The subcutaneous division of the tendo Achillis is then of the greatest value, and is usually unattended with any evil results.

The principal impediments to the reduction of a fracture, in addition to muscular spasm, to which allusion has already been made, are (1) the impaction of the ends of bone, when one fragment is firmly wedged into the other; (2) the presence of a loose fragment, so placed as to obstruct the return of the principal part of the bone into its normal position; and (3) the presence of soft parts (*e.g.* a piece of muscle) between the ends of the bone. If the fracture is

impacted it is occasionally necessary to use force to disentangle the fragments, though sometimes a slight rotatory movement will accomplish the object. But if any serious difficulty is experienced in reducing the deformity, it is better to let it remain, unless it renders the limb absolutely useless, than to use excessive force in attempting to overcome it. When a fragment of bone is so situated as to prevent reduction, it is probable that the cause will not be ascertained and the surgeon will have to content himself with placing the limb in as favourable a position as possible for the future welfare of his patient, taking care at the same time to inform him that owing to some unpreventable cause it is impossible to place the bones strictly in apposition, and that he must be prepared for a certain amount of deformity and impaired usefulness of the limb. For even if the cause of the inability to reduce the fracture from a misplaced fragment were known, it would not, in the majority of cases, be justifiable to cut down and remove it and thus convert a simple into a compound fracture. The only cases in which such a proceeding is allowable is where the fragment is so prominent as to cause pressure upon the skin and render sloughing a matter of certainty or at all events of extreme probability. The same remark applies to the presence of a piece of muscle or any soft part between the ends of the bone. If the structure, whatever it is, cannot be disengaged by any of the various manipulations such as extension, flexion, or rotation, it must be allowed to remain, rather than convert the simple into a compound fracture. Though it must be confessed that this course is likely to result in a want of union, still, the uncertainty which must surround the cause of the inability to reduce a fracture would justify the surgeon in waiting until the future progress of the case determines the course which should be pursued.

2. **The prevention of the return of the displacement.**—The ends of a broken bone, having been placed in apposition, will not remain so unless means be taken to prevent their becoming again displaced. The causes which conduce to this result are three: first and principally, muscular contraction; secondly, the movements of the patient; and thirdly, the weight of the limb. It must be borne in mind that the muscles are active moving forces, which, if not controlled, will speedily reproduce the same deformity which they originally occasioned, and therefore means must be taken by suitable appliances to prevent this from taking place. Again, any movement on the part of the patient, the continuity of the bone having been destroyed, tends to move the one fragment on the other and thus occasion a displacement of the newly set fracture. Lastly, if the limb is not supported on a firm basis, its own weight has a tendency to produce a displacement of the fragments. In arranging, therefore, an appliance by which the fractured ends shall be maintained in apposition until consolidation has taken place these three ends must be borne in mind. The appliance, whatever it may be, must be of such a nature that it will control the action of the neighbouring muscles and will prevent them during their contraction from pulling on the broken ends of the bone. This is done by applying the means in such a manner that the offending muscles are kept in a state of relaxation, or by arranging some apparatus as shall fix the limb and prevent the muscles, though they may be in a state of contraction, from displacing the fragment. Secondly, the appliance must be arranged in such a manner that the involuntary movements of the patient shall not be communicated to the broken bone, except as a whole. This is especially essential in children and in patients suffering from delirium, who cannot be made to exercise

their will in controlling their motions. Lastly, the broken limb must be arranged so that its weight is removed and every part of the limb equally supported. Furthermore, all pressure on prominent points must be avoided, so that no undue pressure is made on any one particular part.

The various means used for retaining the fractured ends of a bone in apposition are as follows: (1) Bandages; (2) splints; (3) hyponarthetic and special apparatus; (4) immovable apparatus.

1. **Bandages** are sometimes the only appliances available for maintaining the fractured bones in apposition; as, for instance, in fracture of the clavicle, ribs, or pelvis. In applying them care must be taken that they press evenly on every part and are not applied too tightly.

It was formerly the practice of surgeons to bandage the broken limb before applying splints. There can be no doubt, however, that this was a great error. The application of a bandage to a fractured limb in this manner is fraught with danger, often producing inflammation and gangrene, and frequently attended with great pain. In addition to this it removes from view the seat of fracture so that the surgeon is often unable to ascertain the condition of the parts. The only circumstance under which a bandage beneath the splint is admissible is in order to prevent œdema below the seat of fracture. Thus, in fracture of the humerus it is allowable and sometimes advisable to apply a bandage to the fingers and fore-arm to prevent œdema, but in no case should it be brought above the elbow.

Splints are employed in the treatment of fractures for two purposes: in the first place and principally, in order to maintain the fractured ends of the bone in apposition after reduction; and secondly, to supply a means by which the requisite amount of extension

may be kept up so as to prevent shortening from the action of neighbouring muscles. The first object is generally attained by placing two splints one on either side of the limb; but occasionally four splints, encircling the limb, are employed, the object being to obtain perfect steadiness of the fracture, without pressing upon it. Extension is maintained by fixing one end of the splint, which generally under these circumstances is of considerable length, to the limb below the point of fracture, and then, the member having been extended to the requisite degree, the upper end is fixed by some convenient apparatus. For instance, in a fracture of the thigh a leather strap is passed round the perineum and over a notch in the top of the splint.

Many materials have been employed for the manufacture of splints; wood, zinc, iron, tin, copper, leather, guttapercha, felt hardened by shellac, pasteboard, mill-board, rattan cane, reeds, straw, willow branches, and many other materials have been recommended, and all have their advocates. There is no doubt that for general use and in the majority of cases a splint made of some light wood, such as deal, is the most efficient and the best adapted to the treatment of fractures. Metal splints are exceedingly cumbersome and heavy, and possess no advantage over the wooden splint. For though splints of the more malleable metals are capable of being moulded to the limb, the process is one entailing considerable labour, and after all, the splint is rarely found to exactly fit the part. A form of perforated zinc splint is extensively used in the United States army, and is said to be light and useful. Leather and guttapercha are frequently found useful in the manufacture of splints, especially in fractures of the upper extremity and in situations where it is impossible to apply an ordinary wooden splint, as in fractures of the neck of

the humerus. Felt, pasteboard, or mill-board, are generally used in the later stages of a case of fracture; that is, after all swelling has subsided and partial consolidation has taken place; thus enabling the patient to get up and move about on crutches. They are also employed sometimes in the treatment of fracture from the first, and will be again referred to under the heading of immovable apparatus. The rattan cane splint was at one time extolled in the treatment of fractures, especially those of the upper extremity, but appears now to have fallen into disuse. It consists of a number of pieces of cane of the required length, sewn side by side between two pieces of "ticking" or stout calico. The splint possesses the advantage of being light and clean, as it does not readily absorb any discharge which may be present. Reeds, straw, and willow branches have been employed in the formation of a particular form of splint, which from its construction from reeds is called a junk (*juncus*, a reed). The reeds or straw are quilted between two pieces of calico, so as to form a sort of cushion of sufficient size to encircle three sides of the limb. This is strapped on, and is a most useful contrivance in cases where there is much swelling or where the patient is delirious, as it allows a certain amount of movement of the limb as a whole with little risk of doing harm to the injured part. It is a useful form of splint to be familiar with, because it can always be improvised, especially for fractures of the leg, when the proper splints cannot be obtained. A small blanket must be folded until it is about two feet long by one and a half broad and about three or four inches in thickness. An ordinary broom handle must be sawn in two and stitched in the two ends of a piece of strong calico, a shade larger than the folded blanket. The splint is now ready for use, and forms an admirable junk for a fractured leg. The blanket is

laid on the calico and the leg on the blanket, and the fracture having been reduced, the splint is strapped tightly round the limb with two straps, one at the ankle, the other at the knee. On an emergency, many articles generally to be found in any house may be utilised in forming a very serviceable splint; a piece of deal plank, the sides and lid of a cigar box, a bandbox, a piece of cardboard, and even an old hat, will often be found extremely useful in forming an impromptu splint.

All splints must be carefully padded with cotton-wool or tow, or, what is perhaps better, on account of its greater elasticity, sheep's wool. The padding must be evenly distributed, so as not to be lumpy and uncomfortable and should overlap somewhat the edges of the splint.

Splints are generally fastened to the limb by webbing or bandages. The former is the preferable material in most cases. A stout piece of webbing, with a buckle attached at one end, is made to encircle the limb above and below the fracture. By tightening the buckles the splints are attached to the limb with any degree of firmness required, and if two splints only be used the seat of the fracture is exposed to view, and any displacement, should it occur, is at once detected.

In selecting and applying the proper splints for any case the following rules should be borne in mind. (1) That they should be as simple as possible, so long as they are efficient; (2) that they should be sufficiently broad to extend beyond the limb, when applied, so as not to press upon it; (3) that, as far as possible, they should be sufficiently long to embrace the joint above and below the seat of fracture; for instance, in fracture of the leg the splints should extend above the knee and below the ankle. This rule, however, is not capable of universal application; as, for instance, in the humerus, where the necessary flexion of the elbow

would prevent the anterior splint, at all events, from projecting beyond the joint; (4) in applying the splints care must be taken that they do not unduly press upon any prominence of bone; (5) that neither the splint or the bandages press upon the fractured part, and (6) finally that they should not be so applied as to impede the return of venous blood and thus cause œdema, or to arrest the supply of blood to the limb and occasion gangrene.

In addition to the extension which can be maintained by splints, it is often useful to employ a weight and pulley as a means of keeping up permanent extension. This is principally applicable to fractures of the lower extremity, and is especially useful in children. The weight is attached to the foot by a broad stirrup of adhesive plaister and a string which plays through a pulley connected to the end of the bed. American surgeons are accustomed to employ this means alone for making extension in fractures, even of the femur, and in this country it is frequently used for the same purpose, and also as an adjunct to the long splint. Dr. Swinburne strongly recommends treating fracture of the long bones by mere extension, regarding splints not only as an unnecessary application but as one which may do mischief.*

Mr. Spence also states that in treating fracture of the thigh, he rarely uses the long splint; he has, he says, found the method by extension so simple and effective, so much more comfortable for both patient and surgeon, that he unhesitatingly recommends the method to all who may not have tried it.†

Hyponarthetic and special apparatus.—By the term "hyponarthetic apparatus" is meant a trough in which the limb is fixed, leaving its anterior surface exposed to view. They are generally known under

* *Med. Times and Gazette*, vol. ii, p. 142; 1861.
† *Ibid.*, vol. ii, p. 205; 1875.

the name of "fracture boxes," and are particularly useful in compound fractures of the leg, as they leave the wound exposed, so that it can be dressed without interfering with or running any risk of disturbing the fracture. They are generally made with a movable foot piece, which slides in a groove in the box by means of a screw, so that the requisite amount of extension can be made by simply turning the screw.*

Innumerable forms of special apparatus have been recommended by different authors at different times, of which it would be impossible in this place to give even a summary. Moreover, their use in the treatment of simple fracture is very rarely indicated. They are costly, and ought to be made especially for the case under treatment. This takes time, and very often when completed they will be found not to accurately fit the limb. And, as Mr. Erichsen says, "a surgeon of ordinary intelligence and mechanical skill may be fully prepared to treat successfully every fracture to which he can be called by having at hand a smooth deal plank half an inch in thickness, and a sheet of guttapercha, undressed sole leather, or pasteboard, to cut into splints as required."

Immovable apparatus.—Of late years the plan of treating fractures from first to last by means of an immovable apparatus in which the limb is encased has been advocated by some surgeons. The materials employed are principally plaster of Paris, starched bandage, gum and chalk, silicate of soda and glue. The advantages claimed for this plan of treatment are, that there is perfect coaptation to irregularities of the limb, and therefore less chance of displacement; uniform compression and therefore a

* The old-fashioned Assalini's box is perhaps the best example of this form of apparatus, though it appears to have fallen into disuse at most hospitals. It is constantly used at St. George's Hospital with the best results.

diminution of spasm; no injurious pressure on bony prominences, and more complete fixation of the fragments, so that prolonged confinement to bed is unnecessary; the patient being able to get up and go about on crutches, and even carry on his business during the whole of the treatment.

The objections to a strictly *immovable* apparatus are that it entirely prevents our ascertaining what is going on at the seat of fracture; that should swelling come on there is often much difficulty in removing the case, and that in the course of a few days after it has been applied it may become loosened from shrinking of the limb and a second "case" may be required. Various plans have therefore been introduced for converting the *immovable* into a *movable* apparatus; and the "movable-immovable" apparatus in some form or other is now extensively used and advocated by some surgeons. Plaster of Paris is the material which has been most extensively employed. It may be used in several different ways.

The ordinary plan is to rub plaster of Paris thoroughly into the meshes of a coarse muslin or calico bandage. A piece of blanket or a flannel roller is first applied, and the plaster of Paris bandage having been wetted is smoothly rolled over the limb, while assistants keep up extension and maintain the fragments in apposition. Between each bandage a quantity of the plaster mixed with water to form a material of the thickness of cream is rubbed in with the hand. In this way three or four bandages are applied. It dries in the course of a few minutes and forms a hard and solid casing. The objection to its use is the difficulty with which it is removed, and the fact that it cannot easily be converted into the movable form of splint. The best means of removing it is to make two vertical sections about an inch apart, almost through the plaster, with a sharp knife; the intervening piece is

then raised at the top and the section completed by alternate nicks on either side.

Another means of removing it is by the application of muriatic acid sufficiently diluted to have no action on the skin. This renders the plaster so soft that it can be cut with a penknife or pair of large scissors. The solution may be formed by one part of acid to two of water and should be applied over the breadth of two or three fingers. In about ten minutes it will be ready for division.

In order to convert the immovable plaster case into a movable one, the following plan was largely adopted in the Bavarian army during the Franco-German war in fractures of the leg, and hence the splint is called the "Bavarian plaster of Paris splint."

Two pieces of flannel, about twenty inches broad and some inches longer than the injured leg, are to be sewn together down the middle for the length of the leg; and for the rest of their extent slit up in the middle line. The flannel is then to be placed under the leg so that the seam reaches from the ham to the point of the heel. The innermost layer of the flannel is now folded over the limb, the slit portion at the end being brought under the sole of the foot. The leg is placed on one side, the fragments having been adjusted and maintained in position by extension, and a layer of plaster of Paris, mixed to the consistence of cream, evenly spread over the leg between the two layers of flannel. The plaster is carried quite back to the seam behind and to the middle line in front. The outer layer of flannel is now pressed over the plaster before it sets, and cut off where the plaster terminates in the middle line in front. The free border of the inner layer is turned backwards over the anterior border of the casing and fixed to the outer layer of flannel. As soon as the plaster has set, the limb is turned over and the process repeated on the other

side. By this means two accurately moulded side splints are fashioned, which can be taken off and re-adjusted at will, the seam behind forming a hinge (Fig. 10).

Neudorfer applies plaster of Paris splints by dipping strips of linen or lint in the plaster mixed to the consistence of an ordinary poultice, applying them longitudinally to the limb, and keeping them in position with an ordinary bandage.

Croft somewhat modifies the Bavarian method by

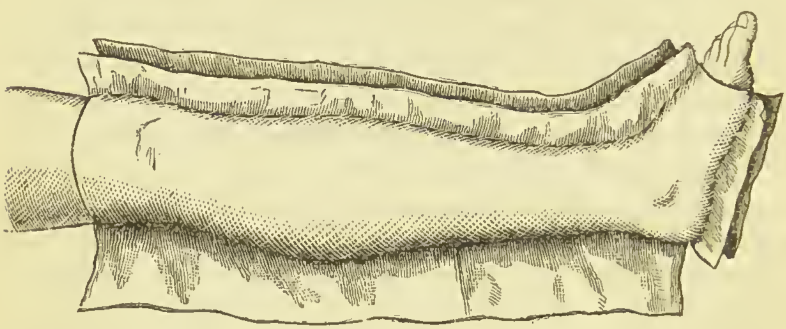


Fig. 10.—Bavarian Plaster of Paris Splint.
The figure shows the flannel adjusted to the limb before the application of the plaster of Paris.

making side splints of plaster of Paris, instead of employing a single splint which embraces the whole limb. They are shaped like ordinary side splints, and are made of two layers of common house-flannel, the outer one of which is well saturated with plaster of Paris, the inner one forming a lining which protects the skin. They are moulded to the limb while in the process of setting, and are maintained in apposition by a muslin bandage, which can be slit up in front in order to examine the fracture, and they can be re-adjusted by another bandage.*

Dr. Little describes another method of applying plaster of Paris splints, which is specially applicable to

* Med.-Chir. Trans., vol. xliv., p. 295.

cases of compound fracture, since it leaves the front of the leg exposed. A piece of coarse washed muslin is obtained of such a size that when folded into four it is sufficiently long to extend from the back of the knee to five inches below the heel, and sufficiently wide to envelop more than half the circumference of the limb. This is dipped in a solution of plaster and quickly folded into four and laid on a board. The limb, with the fracture "set," is then laid on the muslin and the splint folded on the limb. The portion projecting beyond the heel is turned upon the sole, and the sides folded over the dorsum. A bandage maintains it in position until it sets, when the bandage may be removed. A strip of adhesive plaister, above and below, keeps it in position and firmly adjusted to the limb.*

Some surgeons, following the plan advocated by Sentin, have preferred starch to plaster of Paris as the material from which to form the splint. This material has been strongly recommended by Erichsen, who thus describes his mode of applying it. "The limb is first enveloped in a layer of cotton wadding, and over this are laid splints of thick and coarse pasteboard soaked in thin starch. In children, and where much strength is not required, brown paper may be substituted for the pasteboard. A bandage saturated with thick starch is now firmly applied; and lastly, this is covered by another dry roller."

W. Roser recommends a starch-gypsum bandage. According to him the starch is durable; the plaster of Paris has the advantage of immediate firmness. He first applies the starch bandage and then immediately the plaster of Paris. In a day or two, when the starch is quite hard, the outer casing can be removed.

Glue, gum, and chalk, have been substituted for starch, as a material for stiffening the splints. They

* *American Med. Times,* vol. ii., p. 367; 1861.

are not, however, so strong, and thus are less efficient for support and less reliable.

Lastly, silicate of soda, or "soluble glass," has been recommended, especially by the American surgeons. It forms a splint of great lightness, cleanliness, and strength. It dries with greater rapidity than starch or gum, but not so rapidly as plaster of Paris. As a splint for children I have used it with much satisfaction, its great lightness rendering it especially useful in these cases.

In considering the applicability of these immovable apparatus to the treatment of fractures, we must allude to them as applied by different surgeons in two different ways. Some surgeons recommend their employment from the very first; they put the limb up in the fixed apparatus *immediately* after the reduction of the fracture; others employ them only in the later stages of the treatment of the case. That is to say, the limb is first of all "put up" in the ordinary wooden splints, until all swelling has subsided, and is then encased in an immovable apparatus until the fracture has firmly consolidated. There is, no doubt, much to be said in favour of the immediate employment of this apparatus. That, by its means, "it is scarcely ever necessary to keep patients in bed with simple fracture of the leg for more than six or seven days,"* is a great point in saving much of the tediousness and danger of the treatment. For I think that few surgeons will agree with Malgaigne in saying, that "for the patient to leave his bed is of no therapeutic utility." Still, it must be confessed that there is another side to the question, and that by the employment of this method the patient is subjected to the chances of œdema, sloughing, gangrene, and faulty or imperfect union, which no amount of care or attention on the part of the surgeon may be able to avert.

* Erichsen; "Science and Art of Surgery," p. 367. 7th edition.

The very different estimates which have been formed of this mode of treating fractures, which it is impossible to reconcile, should make us adopt it with caution. That there are some cases of simple fracture which may be treated in this way no one, I imagine, would, in the present day, deny.

Thus, in simple fractures without much displacement, and without any great amount of injury to the soft parts, there is probably little risk in at once putting it up in a fixed apparatus. Provided always that the apparatus is so arranged that it can, at any moment, be converted into a movable one, so as to allow of an inspection of the part. For in the treatment of every fracture, no matter of what sort or kind, the old rule of keeping it under observation for the first two or three weeks should be rigidly adhered to, and if the immovable apparatus is used, it should be opened up after it has been applied a few days in order to give the surgeon an opportunity of inspecting the injury.

Then, again, there are other cases where the immediate application of the fixed apparatus is indicated. In military surgery, where the wounded soldier has, perhaps, to be transported to some distance ; in young children who cannot be kept quiet ; and in old persons where there is fear of bed-sores or hypostatic congestion of the lungs ; and, perhaps, in patients suffering from delirium. In these cases, provided there is not much swelling or bruising of the soft parts, the application of this form of apparatus is proper ; but it must be borne in mind that, as Hamilton says, "it demands extraordinary attention."

In the majority of fractures, however, we shall, I think, be best consulting the welfare and interests of our patient by not applying the immovable apparatus until after the subsidence of all swelling. This may be, in a case of a simple fracture of the

leg, in the course of a few days, or it may not be for a week or two. It is then that this form of apparatus will be found of so much value, and that it can be applied with perfect safety. It enables the patient to get up, at the end, it may be, of a week or ten days, and to go about the ward, or even to return home, and, at the same time, is not a source of constant anxiety to the surgeon, and does not require almost daily supervision.

3. **Constitutional treatment.**—In the treatment of a case of simple fracture the habits of the patient must be interfered with as little as possible. If the fracture is in the upper extremity it is not necessary to confine the patient to bed under ordinary circumstances; although in some special cases, to which allusion will be made later on, confinement to bed forms a part of the treatment. In fractures of the lower extremity, on the other hand, it will be necessary to keep the patient confined to his couch until such time as it is judged expedient to put the fracture up in some immovable apparatus. Under these circumstances two points must be borne in mind, viz. that, in consequence of the patient not getting his customary exercise, he will, in all probability, not be able to digest his ordinary amount of food, and, secondly, he may suffer from constipation. Attention will have, therefore, to be directed to his diet and to the state of his bowels. The diet should be of a light and nutritious character, the amount of animal food to which the patient is accustomed being reduced, and, except under extraordinary circumstances, being taken only once a day. Stimulants, if the patient is in the habit of taking them, should only be given in small quantities. If symptoms of dyspepsia or indigestion present themselves they must be combated by careful regulation of diet and medicines. It is as well, if possible, to allow the bowels to remain quiet for the

first day or two after the receipt of a fracture of the lower extremity, as the necessary movements during the action of the bowels have a tendency to displace the splints. A gentle aperient should then be exhibited, care being taken to avoid all violent purgation, since the repeated action of the bowels would be prejudicial to maintaining the fracture in position. If constipation ensue the daily administration of a mild laxative is necessary.

In old people there are two special dangers to be apprehended from the enforced confinement to bed: viz. hypostatic congestion of the lungs, and bed-sores. These are especially liable to occur in cases of intracapsular fracture of the neck of the thigh bone. In these cases great care must be bestowed to prevent these untoward results. The former, by propping the patient up in bed, if possible; the latter, by the use of a water-pillow and by scrupulous cleanliness after the use of the bed-pan. If either of these evils should occur, the patient must, at all hazards, be got up, the fracture being done up in an immovable apparatus; or else, if this cannot be done, by following the advice of Sir Benjamin Brodie, "allowing it to take care of itself."

Treatment of compound fractures.—In many cases of compound fracture the first point which the surgeon will have to consider and decide upon is as to whether amputation is necessary or not. In a considerable majority of cases this question does not arise, but in a certain number the injury is so extensive that it will become a matter for serious consideration whether, in order to save the patient's life, it may not be necessary to sacrifice his limb. We must remember also, in coming to a decision on this point, that though our endeavour, primarily, is to preserve the life of the patient, we have also a second object in view, namely, to secure to the

sufferer a useful member; and it must always enter into the surgeon's calculations, in determining upon the propriety of amputation, whether the saved member will afford the patient as good a means of support as would an artificial limb; the chances of surviving an operation, on the one hand, and of living through the protracted process of reparation on the other, being weighed in the same balance.

It having been determined to attempt to save the limb, there are several points which require consideration: (1) the reduction of the fracture; (2) the means to be taken to maintain the broken ends of the bone in apposition; (3) the treatment of the wound; and (4) the treatment of the consecutive inflammation.

1. **The reduction of the fracture.**—Sometimes this is a matter of extreme simplicity; at others it is attended with considerable difficulty. In a large number of cases, especially in those where the bone does not protrude through the wound, the rules laid down for the reduction of a simple fracture are to be followed out in the case of a compound one, and the ends of the bone may be placed in apposition without any difficulty.

Sometimes, however, the end of the bone protrudes from the wound, and, if this is small, the bone is tightly gripped, and there is a great difficulty in disengaging the fragment and effecting reduction; more particularly if there is much spasm of the muscles. In such cases as these it is advisable to administer an anæsthetic rather than endeavour to overcome the contraction of the muscles by violent efforts of extension. The patient being thoroughly under its influence, an attempt must be made, by extension and counter-extension, sometimes combined with gentle lateral movement, to disengage the fragment. The insertion of a blunt hook into the wound, and careful

traction on its margin, which tightly girts the bone, will sometimes succeed in disengaging it. Should these attempts fail, it will be necessary either to enlarge the wound or to saw off the projecting end. If this has been absolutely denuded of periosteum, and especially if it is a sharp splinter from a very oblique fracture, perhaps the latter is the wiser course to pursue; bearing in mind that only so much of the bone is to be removed as will permit of reduction. Under other circumstances the wound must be carefully enlarged; generally in the direction of the axis of the bone, as this will best free the projecting fragment. Occasionally, in fractures of the leg, where there is great over-riding of the fragments, division of the tendo Achillis will materially assist in effecting reduction. All fragments of bone which are found lying loose in the wound must be carefully removed; other fragments, which are still connected to the bone by their periosteum, are to be allowed to remain. It sometimes happens that the difficulty in reduction is due to the presence of a displaced fragment. If this should be discovered it must be removed.

2. **The means to be taken to keep the broken ends of the bone in apposition.**—After the fracture has been fairly set, it must, if possible, be put up in such a manner as to leave the wound exposed, in order to allow of the necessary dressings being applied without disturbing the fracture. It is in cases of compound fracture of the leg that the various forms of hyponarthetic apparatus, such as the fracture boxes of Assalini and MacIntyre, are especially useful, as they leave the front of the limb exposed, so as to permit of the necessary dressing of the wound. The plaster of Paris mould of Dr. Little (*see* page 56) may also advantageously be used in these cases. In compound fractures of the thigh, an "interrupted" long splint, with the "interruption" opposite the seat

of fracture, permits of the wound being dressed without disturbing the position of the fragments.

3. **The treatment of the wound.**—This will depend entirely on its size. If the wound is small, it may be a mere puncture of the skin from the end of the bone, there can be no question that the correct treatment is to endeavour to convert the compound into a simple fracture, by attempting to obtain healing of the wound in the skin without suppuration. This is best done by covering the wound with an artificial scab, and thus promoting "union by scabbing." For this purpose there is nothing so useful as a pledget of unravelled lint, soaked in the patient's blood, placed over the wound, and covered with a pad of dry lint, which is securely strapped in position. The blood coagulates in the meshes of the lint and forms an air-tight "scab," under which union often takes place without any untoward symptoms. Some surgeons recommend collodion or lint soaked in friar's balsam, but in my experience they are far inferior to the scab formed by the patient's blood. In this way, many a compound fracture, where the wound is small, clean cut, and without much bruising, may be converted into a simple fracture, and the patient saved many weeks' confinement to bed.

But when the wound is large, with contused and lacerated edges, with considerable laceration of the soft parts, and, it may be, comminution of the bone, this plan of treatment is of no avail, but probably prejudicial. Under these circumstances there is no plan of treatment which will give such favourable results as the antiseptic treatment of Sir Joseph Lister. Even though the injury has been inflicted for some time before the patient comes under the surgeon's care, and when the soft parts have been extensively bruised and torn, and possibly engrained with dirt, the adoption of this plan of treatment is often followed by the best

results, union sometimes taking place without the formation of a single drop of pus and without the occurrence of any general febrile reaction. And even if such a favourable result as this does not occur, nevertheless, under this plan of treatment, if properly applied, it may be confidently expected that the amount of suppuration will be comparatively little, the general traumatic fever almost nil; and those serious complications, such as deep infiltrations of the areolar planes, with severe constitutional irritation, which so commonly occur in compound fractures, will be altogether avoided.

In these severe cases of compound fracture some surgeons prefer to treat the wound by the open method, applying merely water dressing or carbolised lotion from the first; so as to allow free vent for the discharge. Under these circumstances, free suppuration must necessarily occur, with its attendant dangers of hectic and exhaustion. They object to the treatment of closing the wound; fearing that purulent infiltration of the tissues will ensue, with possibly septic poisoning. This, however, ought not to occur if antiseptic treatment be thoroughly carried out; at all events, this plan will, I believe, be found to give the best results in the largest number of cases.

4. **The treatment of the consecutive inflammation.**—Should inflammation supervene during the progress of a case of compound fracture, an endeavour must be made to moderate it and lessen constitutional irritation. The wound must be left open so as to permit of free drainage, and even, if necessary, a counter-opening made, and a drainage tube inserted, to prevent the burrowing of matter. If unhealthy suppuration and sloughing take place in the neighbourhood of the wound, free incisions, to relieve tension, are required. If constitutional irritation be present it must be combated by opium, care

being taken to keep the bowels open, and the diet regulated according to the requirements of the case. In some instances, especially in drunkards, stimulants will be required from the first; and, in most cases, where there has been extensive suppuration, hectic will supervene in the later stages of the case, requiring as much nourishing diet as the patient can take, and the free exhibition of stimulants and tonics, such as bark, with ammonia or the mineral acids.

Treatment of the Complications of Fractures.

1. **Of fracture complicated with some injury to an internal viscus.**—In these cases the danger depends more upon the injury to the internal organ than to the fracture, and no general rules can be laid down for the treatment of the latter. It is obvious that whatever plan is adopted, care must be taken to prevent the fractured bone from doing any further damage to the injured organ; but the treatment, in the main, must be directed to combating the effects of the injury on the internal viscus, which will demand more urgent attention than the fractured bone, which must be dealt with according to the requirements of each particular case. Should the patient survive the injury, the future treatment of the fracture will be the same as in an uncomplicated case.

2. **Of fracture complicated with injury to some vessel or nerve.**—Here the treatment must necessarily differ, according to the nature of the injury and the effects which it produces. If the main *artery* of the limb is extensively torn a diffused traumatic aneurism will be the result. In these cases, gangrene of the limb will probably ensue, and amputation will be the only resource. In other cases the artery may be only partially torn across, or may be simply punctured by a spiculum of bone; in

these cases, though a traumatic aneurism, either of the diffused or circumscribed variety may form, sufficient blood may find its way down the injured vessel to maintain the vitality of the limb, and no gangrene will result. In such cases pulsation will probably be felt in the arteries below the seat of the injury. Under these circumstances the surgeon has two alternatives: (1) to lay open the tumour, and search for and secure the artery above the point of rupture; (2) to compress or tie the vessel on the cardiac side of the rupture.

There can be little doubt that the simpler measure of arresting the flow of blood through the artery by means of digital pressure, or a horse-shoe tourniquet, should be first tried, and, should this fail, the vessel should be ligatured on the cardiac side of the injury; an operation which has been performed on several occasions with success. The plan of laying open the swelling and searching for the injured vessel is dangerous and difficult. Dangerous, because it converts the simple into a compound fracture at the bottom of a large suppurating cavity, and difficult, because the surgeon would have to grope in the midst of bleeding and infiltrated tissues, among which the artery would be recognised with difficulty.

If a large *vein* is injured, such as the internal jugular in a case of fractured clavicle, death will probably result; if a small vein is wounded no treatment is necessary, even if the exact nature of the lesion be ascertained; the bleeding will probably be arrested after a time, and the effused blood absorbed.

Where a *nerve* is injured there are no special rules to be laid down for its treatment. It may only have been bruised, when the natural processes will in all probability be amply sufficient to effect a cure. The fact that it has been divided will only be evidenced by the permanent loss of power. Under these

circumstances, after the fracture has united it may be deemed advisable to expose the ends of the nerve, and suture them together.

In compound fractures all wounds of vessels and nerves are, of course, to be dealt with as in simple wounds. Arteries must be tied or twisted, and nerves, if divided across, sutured together.

3. **Of fractures complicated with injury to some neighbouring joint.**—When a fracture extends into a joint the surgeon must bear in mind in carrying out his treatment, that impaired mobility of the joint will very probably ensue, and the limb must be put up in the most favourable position for anchylosis. All his endeavours must be directed, however, to prevent this, if possible, and it is right, in these cases, to begin a course of passive motion as early as possible; that is to say, as soon as the ends of the broken bone have become sufficiently consolidated to bear the slight strain put upon them by a gentle movement of the articular surfaces on one another.

4. **Of fracture near a joint, complicated with dislocation.**—When merely a portion of the bone has been broken (as in fracture of the coronoid process, in dislocation of the elbow joint, or fracture of the internal malleolus, with dislocation of the ankle), so that the shaft of the bone is intact and can be used as a lever, the treatment presents no difficulties of a special nature. The dislocation is to be reduced in the ordinary way, and the fracture put up with the broken ends of the bone in apposition. But where a fracture of a joint is complicated with dislocation of the separated fragment, the injury is of a very serious nature. Such an accident, for example, occasionally occurs in the neighbourhood of the shoulder joint, where we get a fracture of the neck of the humerus and a dislocation of the head of that bone. There are

three courses which the surgeon may pursue. In the first place, the patient should be thoroughly anæsthetised, so as entirely to relax his muscles, and then an attempt should be made, by pressing firmly on the displaced head of the bone, to push it back into its place. This may sometimes be satisfactorily accomplished, especially in fracture of the anatomical neck of the humerus, as there are no muscles inserted into the head of that bone which, by their contraction, would prevent its reduction.* Failing this, the fracture must be put up very firmly in wooden splints, so as to maintain the fractured ends in apposition, and an attempt made to reduce the dislocation in the ordinary way. It is of great importance that every effort should be made to replace the head of the bone at once; but, should they not be successful, the surgeon has no other resource but to put the fracture up with the dislocation unreduced, and to wait until union has taken place; after which he may try to restore the head of the bone to its natural position. This proceeding, however, is, after the length of time which has elapsed since the bone was displaced, extremely difficult, and the attempt, in many cases, will result in failure. Should this be so, an endeavour must be made to form a false joint, and thus give the patient as extensive a range of motion, and as useful a limb, as circumstances will permit.

CHAPTER VI.

COMPLICATIONS DURING TREATMENT.

DURING the treatment of a case of fracture many complications may arise: some of which are of minor

* *See* cases in the *Edinburgh Medical Journal*, vol. viii., p. 1084; and *British Medical Journal*, vol. i., p. 140; 1862.

importance, others of the gravest nature. They may be considered under the following heads: (1) Local complications; (2) general complications; and (3) special complications of compound fractures.

1. The principal local complications which may occur during the treatment of fracture are œdema, suppuration, gangrene, and spasm.

Œdema may occur in the earlier period of the case, as the direct result of the injury. Under these circumstances it is of comparatively little importance, and subsides of itself when the fractured bones have been placed in position. Later on œdema may occur from bandages applied too tightly, or from the limb being allowed to remain in a dependent position. This is of much greater importance than the former; for not only is it indicative of a tendency to gangrene if not relieved, but it adds greatly to the sufferings of the patient, and, from impairing the nutrition of the tissues, renders them liable to slough under very slight pressure, and, probably from the same cause, delays the union of the fracture.

Lastly, œdema may be caused by thrombosis, or plugging of the large veins of the limb, the thrombosis beginning either in the veins in the immediate neighbourhood of the injury, or, as Sir James Paget has pointed out, commencing in some superficial veins by their being irritated by the hard edges of bandages.* The clot then extends from this point until, at last, one vein after another having become filled, a hard solid œdema of the limb ensues. There is a special danger in these cases of sudden death, from a portion of the clot becoming separated and washed into the current of the blood. This form of œdema is also very persistent, remaining for some time after the fracture is united.

Suppuration very rarely occurs as a complication

* *Lancet*, Feb. 27, 1869; p. 287.

of simple fracture if the ends of the bone are maintained strictly in apposition. Occasionally, however, when this is not done (as when the patient, suffering from delirium, cannot be restrained from moving his limb about), it may happen that the extravasated blood breaks down and suppurates. If this is so, and the abscess bursts, or is opened, the simple fracture is converted into a compound one. (*See* page 12.)

Gangrene.—One of the principal causes of gangrene occurring during the treatment of a fracture is undoubtedly too tight bandaging, but it must not be assumed that, therefore, every case of gangrene is due to this cause; since it may without doubt arise also from others. Thus, in addition to those cases of injury to the main artery, causing gangrene (to which allusion has already been made), we may have large extravasations of blood taking place from numerous small vessels which have been torn; and thus, so great a compression of the main arteries of the limb by which the nutrition is carried on that an arrest of the circulation takes place, and gangrene results. So, again, inflammatory effusions may produce gangrene, causing swelling under a bandage, and thus pressing upon the vessels and interfering with the circulation. Cases are also recorded where injury to the nerves, either from the broken ends of the bone or from implication in the callus which has subsequently been formed, has been followed by gangrene.

Gangrene occurs more commonly in those whose tissues are soft and tender, and therefore more susceptible of compression, such as women and children, and is said to occur more frequently in the upper than in the lower extremity.

If gangrene is threatening, after all splints or apparatus have been removed, friction in an upward

direction should be assiduously applied, and the limb kept warm by being swathed in cotton-wool.

After it has occurred, incisions must be made if the limb is swollen and infiltrated, especially if the cause is from inflammatory exudation, and hot fomentations applied. Generally, however, amputation will be necessary, even though the gangrene does not involve the whole of the structures of the limb, as the resulting member will probably be contracted and useless.

Spasm is sometimes one of the most troublesome complications of simple fracture with which the surgeon will have to cope. It arises from the fragments irritating either the muscles themselves, or the nerves supplying them, and is sometimes so severe and uncontrollable as to defy all efforts of the surgeon to overcome it. It causes great pain to the patient, and often considerable displacement of the fragments. As a rule there is always more or less spasm present until the fracture is reduced, but after the replacement of the broken ends of the bone it subsides spontaneously. But in some cases it is of a permanent character, and prevents the maintenance of the broken ends of the bone in apposition, since all attempts to overcome it by force are hopeless. The best plan of treatment is to keep the patient under the influence of opium, administered in full doses, and to place the limb in such a position as to relax the muscles as much as possible. This will generally succeed in allaying or subduing the spasm, and there seems to be no occasion, as is recommended by some, to divide the opposing tendons.

It may be necessary in some severe cases to keep the patient more or less continuously under the influence of an anæsthetic, given repeatedly in small quantities. This will entirely allay the spasms while the effect is kept up, but they will return as soon as the effects of the anæsthetic pass off.

2. The general complications are for the most part such as are common to all injuries, such as delirium, erysipelas, tetanus, etc., and to these must be added bed-sores and hypostatic congestion of the lungs, complications arising as the result of the treatment, especially in old people; and finally one special complication, the direct result of the injury, viz. pulmonary fat embolism.

These conditions require little special comment, since they differ in no wise from a similar condition arising in the course of other injuries, with the single exception of the somewhat rare complication, which has only attracted notice of late years, of fatty emboli, occurring in the lungs, and to a less extent in the other viscera, after fracture. In these cases, the marrow of the bone being crushed by the fracture, it is supposed that some of the liberated fat passes into the veins, and is by them carried to the nearest set of capillaries (that is, those of the lungs) and produces death by interfering with respiration.

Zenker, in the year 1862, first drew attention to this condition. He described the capillaries of the lungs as being loaded with fat in a man who had been crushed between two waggons, but did not connect the condition with the injury. Soon after, it was established, by experimental research, that in cases of fracture there was fatty embolism, not only in the lungs, but in all the tissues, and that the fatty matter was probably derived from the marrow of the broken bones. Finally, it was believed, that in many cases of sudden death after fracture, the death must be attributed to this condition, and not to shock. The symptoms to which this state gives rise are those of dyspnœa, coming on suddenly, perhaps some twenty-four hours or more after the receipt of the injury, with irregularity of the heart's action, coma, and death.*

* *See* a paper by Dr. Czeray, of Freiburg, in *Berl. Klinische Wochenschrift*, No. 44, 1875.

3. There are certain special complications of compound fracture to which allusion must be made. These are necrosis, osteo-myelitis and pyæmia, spreading gangrene, and hectic.

Necrosis is a not uncommon accompaniment of compound fracture. Allusion has already been made to this in describing the union of compound fractures. (*See* page 40.)

Osteo-myelitis, or diffuse suppuration in the cancellous tissue, occasionally occurs as a result of compound fracture, as in other injuries where the medullary cavity of the bone is exposed. It is closely allied to pyæmia, the patient presenting the symptoms of that disease and rapidly dying. The disease is "more frequently recognised in post-mortem examinations than at the bed-side of the patient."

Spreading gangrene is an occasional accompaniment to compound fractures, for though common to all wounds, even the most trivial, under certain conditions, it most frequently occurs in severe contused and lacerated wounds, complicated with fracture, where the tissues are engorged with serum and extravasated blood, a condition peculiarly favourable to its occurrence. In these cases amputation appears to hold out the only chance of recovery. The gangrene speedily extends through the limb until it reaches the trunk, without any attempt to arrest or to form a line of demarcation, and death invariably ensues in the course of three or four days unless the limb be removed above the part implicated.

Hectic not unfrequently ensues in cases of compound fracture, resulting from profuse suppuration. This is most frequently the case where the ends of the bones have become necrosed ; the long-continued process of exfoliation being attended by profuse suppuration, and the constitution suffering from the effects of this wasting discharge. In such a case,

secondary amputation is necessary, and, if it be not delayed too long, until the patient's strength has been too far exhausted, his life will, in all probability, be preserved. Should it be put off too long, there is danger of the patient sinking from shock, or from some low form of inflammatory mischief.

CHAPTER VII.

VICIOUS UNION, IMPERFECT UNION, AND NON-UNION OF FRACTURES.

It rarely happens, now-a-days, that union of a fracture takes place in such a position as to render the limb useless, though such cases do occasionally occur. But a certain degree of deformity, from want of proper apposition of the fragments, must now and then result, in the practice of those who are called upon to treat a large number of cases of fracture, and this in spite of every care and attention on the part of the medical attendant. There is a certain class of cases in which it is impossible to restore to their natural position the fragments of a broken bone; especially if much over-riding has taken place; though the bones can, in most instances, be laid in such a manner as to restore the natural axis of the limb. And again, in some patients, owing to delirium or natural restlessness, it is found to be impossible to keep the fractured ends in apposition; so that a proportion of cases of vicious union must be expected in treating a large number of fractures. Generally, however, this is so slight that the movements of the patient are not impaired, and he is willing to allow the slight deformity to remain.

Vicious union, taking place to such an extent as to impair movement and render the limb more or less useless, may arise from one of three causes: (1) either from the fracture having been badly set; (2) from displacement taking place after reduction, either from great restlessness on the part of the patient, or from too loose application of the bandages; and (3) from yielding of the callus after the splints have been removed.

A fracture may be badly set, either through the want of proper attention and care on the part of the surgeon, who, possibly it may be from the amount of swelling, does not discover that the bones are not accurately in apposition, or from his inability to reduce the displacement. Or, it may be that the fracture has been properly set, but the bones have slipped out of position, and the accident has not been discovered until too late. Another cause of vicious union occurs occasionally in patients who, for some reason, have faulty callus; where the fracture (when the limb is taken out of the splints, at the end of the proper period) appears to be firmly united and in good position, but where the callus is soft, and gradually yields under the weight of the body, so as often to produce great deformity.

The displacement from faulty union may be either angular or longitudinal. The angular is where the bone is simply bent at the point of union; a condition which is much more amenable to treatment than the longitudinal, where it is often difficult, and even impossible, to remove the deformity.

If the displacement is angular, and the faulty position is discovered within the first two or three weeks, while the callus is yet soft, the displacement may be overcome by the careful application of splints; if the callus is more firm it may be necessary to place the patient under the influence of an anæsthetic, and

by muscular force bend or break through the bond of union. Mr. Skey strongly advocates re-fracture of badly united fractures before union has become too firm. He has re-broken the femur eleven weeks, and the bones of the fore-arm seventeen weeks, after the original injury.*

If the displacement is longitudinal, with more or less over-riding of the fragments, it will generally be found impossible to restore the bone to its proper position after callus has once formed, by any amount of extension or manipulation that one is justified in using. Various forms of screw and lever machines, of considerable power, have been invented to break through a faulty union, of which, perhaps, the best known is "Butcher's clamp," but these instruments require to be used with the greatest care. And if the unaided force of the surgeon is not sufficient to overcome the deformity, it is better to have recourse to a cutting operation than run the risk of greatly bruising the soft parts, or causing mortification of the skin from pressure of the instrument.

The best means of remedying the defect, in some cases, is by subcutaneous osteotomy. This may either be done by Adam's narrow-bladed saw, or by the plan proposed by Langenbeck. This consists in making a small incision down to the bone, and introducing a perforator, with which the bone is bored. Into the opening thus made a fine saw is introduced, and the bone partially sawn through. The wound is now closed, and, after it has healed, the rest of the bone is fractured by force. Gross recommends that the section of the bone should be made with a chisel.

In some cases a mere section of the bone is not sufficient to overcome the deformity, and then it is necessary to freely expose the fracture, and take out a wedge-shaped piece, before the limb can be restored

* *Lancet*, vol. ii., 1870; p. 395.

to anything like its natural shape.* (*See* Fig. 47.) This should be done with strict antiseptic precautions.

Ununited fractures.—Many different conditions are described as cases of non-union of fracture. Some of these are correctly so called since there is an entire absence of union between the fractured ends of the bones, which move freely on each other, and often become dwindled and diminished in size. Again, there is another class of cases to which the term "non-union" may also with propriety be applied, since there is no actual union between the bony surfaces. There are instances where a false joint (pseudarthrosis) is formed; in which a dense capsule, containing a fluid resembling synovia, is developed around the ends of the bones, which become eburnated and smooth, and thus play freely on each other, and form a genuine diarthrodial joint.

But, in addition to these, there is a large number of cases to which the term is also applied, which would be better described as instances of "imperfect" or incomplete union of fracture. These are cases in which the process of union has commenced, but, owing to some constitutional or local cause, has not gone on to its final completion. Thus the callus may have been poured out between the ends of the bones, and become converted into fibrous tissue. At this point the process has become arrested, and the ends of the bone, instead of being firmly united by bony matter, are connected by a strong ligamentous material, which allows of a considerable degree of movement at the seat of fracture.

Or, again, the process of union may have gone a little farther, and the callus may have become converted into cartilage, which unites, and perhaps

* *See* a case by Mr. Christopher Heath; Clin. Soc. Trans., vol. x., p. 158.

envelopes, the broken ends. In consequence, however, of some arrest in the healing process, calcification and ossification have not taken place, and there is, therefore, an imperfect union, wanting in solidity and strength, and allowing of a certain degree of movement between the broken ends of the bone.

It would seem, therefore, to be more logical to describe under the head of *imperfect union* these two conditions, and to confine the term *non-union* to those cases where there is an entire absence of union, or where a false joint is formed.

In addition to these conditions it is right to mention another state where the process of union is *delayed*, where, in fact, the bone does not unite so rapidly as usual, and where, at the end of some six weeks or two months, when the surgeon examines the fracture, expecting to find the bones firmly united, they are found to be movable on each other, and not to present that firmness and solidity which might naturally be expected. The time, however, which fractures take to unite is so variable, that it is difficult to say when, on the one hand, ordinary union merges into *delayed* union, and, on the other hand, when delayed union may be said to be arrested.

This condition of delayed union is by no means an uncommon one, and will often be found to be connected with a phosphatic condition of the urine. If the urine of a patient, in whom the process of union of a fracture is delayed, is examined, it will be found in the majority of cases to be alkaline or neutral, and to deposit on boiling a copious precipitate. This condition may, perhaps, be explained by the fact, that the patient having been deprived, by the necessary confinement to bed, of his accustomed exercise, does not assimilate his food properly, and this gives rise to excess of phosphates in the urine. At all events, it will generally be found that by careful regulation of

his diet, cutting off a considerable part of his nitrogenous food, and the exhibition of the mineral acids with bark, union of the bone speedily takes place, and the urine recovers its proper characters.

Where the union is imperfect and the ends of the bone united by fibrous material, they will generally be found to be more or less absorbed, and the medullary cavity closed. The fibrous union is, in most cases, found not only between the broken ends, occupying the position of the definitive callus, but also forming a dense layer or sheath around them, and therefore corresponding to the provisional callus. In some bones, such as the patella, union for the most part takes place by fibrous tissue, and the condition can therefore hardly be considered as an imperfect one.

In the mode of union by cartilage the same condition occurs, and often to a much greater extent. Thus, the ends of the bones in these cases are found to be enveloped in a dense mass of ensheathing provisional fibro-cartilage, which gives great firmness to the parts, and therefore the amount of movement between the broken ends of the bone is but slight.

It is very rare to find an entire absence of union. In most cases the broken ends will be found to be connected, to a greater or less extent, by fibrous bands passing from the one fragment to the other, and binding them loosely to each other. But occasionally instances will be met with where nature has not made the slightest effort to repair the injury. It generally occurs in cases where the system is worn out by wasting and rapidly exhausting disease, and where there appears to be no reparative power whatever.

In the false joint the ends of the bones become rounded, smooth, and polished, and covered over with a layer of dense fibrous tissue resembling articular cartilage. In some instances the one bone becomes hollowed out into a cup-shaped cavity, while the other

becomes rounded and conical, and thus a perfect ball-and-socket joint is formed.

The imperfect union or non-union of a fracture is not of frequent occurrence. Markoe states that one in six or seven hundred cases of fracture is probably near the proportion; and Callender states that in the wards of St. Bartholomew's Hospital there had been but one case in two thousand five hundred fractures treated; and other surgical writers concur in the opinion that non-union very rarely occurs.

Causes.—The causes to which this want of union has been attributed are very numerous, and are stated to be either of a constitutional or local nature. The *constitutional* causes which have been said to give rise to a want of union in a fracture are numerous. Amongst these are: (1) Age, either the very young or the very aged; (2) cachexia, from any depressing influence; (3) anæmia, and debility from loss of blood; (4) fevers, especially those of a low type; (5) exhausting diseases, such as phthisis; (6) insufficient or improper food; (7) withdrawal of an habitual stimulus; (8) pregnancy and lactation; (9) profuse uterine and vaginal discharges; (10) scurvy; (11) syphilis; (12) rickets; (13) erysipelas; and (14) gout. To all these different conditions the want of union of fracture has at one time or another been attributed, and, no doubt, with a certain amount of truth, as one or other of these causes may be instrumental in, at all events, retarding, if not altogether preventing, the union of a broken bone; but, at the same time, more stress appears to have been laid on these general causes than they would appear to merit. All these conditions produce a certain depressing influence on the system, in consequence of which there is not sufficient reparative power to carry out the process of union, and it is therefore delayed or altogether absent; and thus they may be regarded as the primary cause of the want of the union.

Age does not appear to have any decided influence in preventing the union of fractures, either as regards the very young or the very old, unless there be some cause superadded to which the failure of union ought more properly to be attributed. As a rule, in the child, fractures unite with peculiar facility; but occasionally it may happen that, probably owing to the great difficulty that there is in keeping the child quiet, and therefore of maintaining the fragments of bone in strict apposition, a failure of union may occur. Under these circumstances the difficulties of the case are great, as the various plans of treatment which are recommended in cases of non-union in the adult are very apt to fail in obtaining the desired end in the ununited fractures of children.*

Old age, also, in itself appears to be no impediment to the pouring out of callus and the union of a broken bone, so long as the patient is fairly vigorous, and there is no other depressing influence interfering with his vital power. The patient from whom the wood-cut (Fig. 41) was taken was within a few months of attaining his hundredth year of age, when he fractured the shaft of his femur, and though, owing to the occurrence of bed sores and the inability that there was to apply any splint, there has been faulty union, still there has been no lack of reparative material.

Perhaps of all the constitutional causes which have been alleged as liable to give rise to non-union of a fracture, syphilis and scurvy are the most probable. Cases are now and then recorded of these two diseases, which seem to point undoubtedly to the fact that occasionally they have some specific influence in arresting natural union. Still, on the other hand, it must be acknowledged that in many cases of syphilis and scurvy, bones are broken and unite in the

* *See* an interesting preparation in the Hunterian Museum, No. 813 A.

ordinary way, without difficulty or delay. So that this influence, whatever it may be, is not a constant one, and only occasionally asserts itself.* Mr. Callender, however, denies that syphilis in any way interferes with union.†

Cases in which scurvy has prevented union or caused already existing union to break down, are also occasionally recorded in the medical journals. And it will sometimes be found that fractures occurring in a person, the subject of scurvy, show little tendency to unite so long as the scorbutic symptoms persist. Mr. Adams records a case where the fracture showed no tendency to unite until lemon juice was administered, when union speedily took place.‡

With regard to the other constitutional causes enumerated above nothing more need be added to what has already been said: that the want of union is probably due to debility and deficiency of reparative power, induced by the constitutional condition rather than to a direct influence of this condition on the fracture itself.

It is to the local causes that we must principally look for an explanation of the reason why a fracture occasionally refuses to unite. There can be no question that the most potent of these is the presence of a certain degree of movement between the fragments which prevents their becoming quickly knit together, and is therefore a cause which is, to a very great extent, under the control of the surgeon. Cases will, however, occasionally occur, either in young children or delirious patients, or where, for some other reasons, it is impossible to maintain absolute immobility between the fragments; so that after all that care and

* *See* an interesting case by Dr. Steele, *Lancet*, vol. ii., p. 627; 1873.

† Med.-Chir. Trans., vol. xli., p. 147.

‡ *Lancet*, vol. i., p. 383; 1885.

skill can do, there will still remain a certain number of cases of non-union where the failure is due to this cause.

Hence, in very oblique fractures, especially in the bones of the leg, it is very often impossible to maintain the fragments in strict apposition, on account of the great tendency which they have to glide over one another, and, therefore, want of union may ensue.

The late Mr. Callender has also pointed out another way in which he believed the obliquity of a fracture may conduce to its non-union, because the whole weight of the man, when he is allowed to put his foot to the ground, falls on and strains the uniting material, instead of pressing directly on the lower fragment, as in a transverse or slightly oblique fracture, which largely assists in bearing the superincumbent weight. Hence the union gives way and repair is incomplete. Still another way in which union may be retarded or prevented from movement of the fragments is also mentioned by Mr. Callender. It is in the case of fractures in the neighbourhood of joints, especially fracture of the lower end of the humerus. When this occurs, the surgeon, in his endeavour to prevent stiffness of the articulation, may commence passive motion of the joint before consolidation of the fracture has sufficiently taken place, and, in his attempts to move the joint, really moves the fragments of the broken bones on each other, and thus prevents perfect union taking place.

Many other local causes, preventing the union of fractured bones, have been at different times put forward.

Mr. Curling believes that a diminished blood supply from injury to the nutrient artery is a frequent source of non-union.

M. Guéretin has collected some statistics bearing on this point. He states that in thirty-five cases of

non-union, ten belonged to that portion of the bone which was traversed by the artery, and the remaining twenty-five to the other portion. The observations of Norris do not, however, confirm this opinion. He collected forty-one cases, in which he found a very different condition. For, in twenty-seven of the cases the ununited fracture was in that part of the bone which was traversed by the nutrient artery, and in only fourteen was it in the part which is supposed to receive the smallest amount of blood.

The late Mr. Callender believed that in many cases the union of a fracture might, at all events, be delayed by obstruction to the venous circulation, producing an œdema of the limb, which impairs nutrition and embarrasses the repair of the fracture. This coagulation, he believes, begins in the veins in the neighbourhood of the fracture, and extends from the lesser to the greater vessels, until it may obstruct even the main vein of the limb.

Loss of nerve power has been cited as one of the causes of want of union in a fracture, but there does not appear to be sufficient evidence at present to support this hypothesis. Thus, in several cases which have been recorded of fracture of the spine with compression of the spinal cord and fracture of some bone in the paralysed part, union appears to have been going on, when the limbs were examined after the death of the patient, though perhaps more slowly than natural.*

The presence of a foreign body between the ends of the fracture must, of course, interfere with union. Thus, the constantly quoted case of Mr. Earl's, where a piece of the deltoid muscle became lodged between the fractured ends of a broken humerus, is an instance in point. So, again, the interposed substance may be a third fragment of bone, separated from all its

* *See* a paper by Dr. Ogle; St. George's Hosp. Reports, vol. vi., p. 275.

surroundings and lying, as a foreign body, between the two main portions of the bone; this must, of course, interfere with union. These cases are, however, extremely rare.

Lastly, necrosis from loss of the periosteum, so that an interval is left between the two fragments, is a cause of non-union.

In thus enumerating the local causes of non-union of a fracture, no mention is made of those cases where the fracture itself was the result of some disease in the bone, such as mollities ossium or sarcoma, and where it is evident that no union is likely to take place, or of those cases where the fragments are so far separated from each other that union is impossible. Both these conditions give rise to non-union, but the cause is so obvious that it is not necessary to do more than allude to them.

Symptoms.—Little requires to be said with regard to the symptoms presented by a patient suffering from non-union of a fracture, as the diagnosis is generally sufficiently clear. The main symptoms are: (1) Pain; (2) deformity; (3) increased mobility; (4) uselessness of the limb; and (5) atrophy or wasting. (1) The pain is not usually of a very severe character, especially after the soft parts have become accustomed to the abnormal position of the bones; and the patient is generally able to move about without causing any great feeling of pain, but rather suffers from a sensation of weakness. (2) Deformity is always present, and sometimes in a marked degree, especially in fractures of the lower extremity and where the patient has attempted to bear the weight of his body on the injured limb. The deformity often partakes of the character of shortening, with more or less angular displacement, and is generally most observable when the patient makes any muscular exertion. (3) Increased mobility is invariably present, but varies in amount; where the

broken ends are linked together by firm fibrous tissue there may be only slight yielding, even when the weight of the body is borne on the limb; and, on the other hand, when there is no union, the movement may be so great as to produce a flail-like condition of the part. (4) Uselessness of the limb varies with the amount of mobility. Where the mobility is slight the usefulness is not entirely impaired; where it is great the limb is most helpless and useless. (5) Atrophy, or wasting, is a consequence of the uselessness; all the tissues of the limb becoming wasted and the bones light and porous.

Treatment.—Perhaps there is scarcely any surgical disease for which so many remedies have been introduced and recommended as non-union of fractures. Considering how uncommon these cases are, it is surprising that so many different plans have been at different times introduced in order to remedy it.

In many cases, it must be borne in mind that the union is only *delayed.* Nature is equal to the task of restoring the bone, but, owing to some cause or other, the various processes go on more slowly than natural, or indeed are arrested altogether for a time. All that the surgeon requires to do under these circumstances is, if possible, to remove the cause which is giving rise to this condition and so assist nature in completing the work. All that is necessary, therefore, in a considerable number of cases, is to improve the condition of the patient's health and to invigorate his system. Often the delayed union appears, in some measure, to be due to impairment of the patient's health, from the necessary confinement to bed. It is advisable, therefore, to get the patient up and into the open air. A change of air, especially to the sea-side, is often followed by the happiest results. The diet must be carefully regulated; nutritious, but at the same time, easily digested food being of the first importance, and

attention must be paid to remedy any irregularity in the digestive organs. Tonics, especially bark, combined with the mineral acids, should be given, and any constitutional taint carefully treated. If there is any suspicion of a syphilitic taint, the bichloride of mercury in small doses, or iodide of potassium, according to the stage of the constitutional affection, should be given. If the patient has any tendency or predisposition to consumption, cod-liver oil must be administered, and if he has suffered from scurvy, fresh vegetables, with lime or lemon juice, should form an essential part of his diet.

In order to permit of the patient getting up and moving about, it is necessary that the limb should be put up in some immovable apparatus, plaster of Paris, pasteboard and gum, or leather splints. The apparatus should be applied in such a manner that the fractured ends are immovably fixed and pressed firmly together. It is the practice of some surgeons, in fractures of the lower extremities, to allow their patients, after the limb has been done up in the fixed apparatus, to put the fractured leg to the ground, in order to excite in the tissues some degree of inflammatory action. The proceeding, however, is not altogether devoid of danger, as suppuration may result; and, moreover, if there be any imperfection in the splint, a slight degree of movement may be permitted between the fragments and the end for which it was applied defeated.

Dr. Henry H. Smith advocates the treatment of ununited fracture or delayed union by artificial limbs, which "combine the principle of pressure and motion at the seat of the fracture and lead to the formation of an ensheathing callus." He records four cases of false joint in the femur, eight in the leg, and two in the humerus treated successfully by this plan.*

* *American Journal of Medical Science*, Jan., 1855; p. 102.

If there is considerable œdema of the limb as in the cases recorded by Mr. Callender, friction in the course of the venous circulation should be regularly applied, and under these circumstances it is better not to put the patient's fracture up in any fixed apparatus or allow him to get up. The limb should be placed in ordinary splints for the purpose of maintaining the fractured ends in apposition, and they can be daily removed for the application of the friction, etc. If there is no very evident cause for the want of union, it will occasionally be found that counter-irritation, applied to the skin over the fracture, causes a certain amount of excitement in the tissues around the fracture and hastens union. Blisters, iodine, and stimulating embrocations may be used. In one or two cases, where union has been delayed, I have found that the application of a blister or two has been of the greatest possible service. Rubbing the broken ends of the bone together for some minutes, so as to excite a certain amount of inflammation in the parts, is also attended sometimes by the best results, and will sometimes succeed when other means have failed.

Galvanism has also been recommended as a means of hastening union; the poles of the battery being applied either to the surface or, as has been recommended by Lente, acupuncture needles are passed down to the bone on either side of the fracture and the poles of the battery are attached to their other ends.

When failure of union has become very chronic, and when there is reason to believe that a false joint has been formed, operative measures will have to be resorted to. These mainly have for their object one of two things. Either the excitation of a certain degree of inflammation between the broken ends so as to lead to the pouring out of callus which shall subsequently be transformed into bone, or the removal of the false joint altogether.

The principal means by which an attempt has been made to excite inflammation in the fragments are : (1) Acupuncture ; (2) subcutaneous section ; (3) seton ; (4) insertion of ivory pegs ; (5) drilling ; (6) pinning of the broken fragments together.

1. **Acupuncture.**—This consists in the introduction of an acupuncture needle between the fragments, and allowing it to remain there until it has excited a certain degree of inflammation, when it may be removed and the limb confined in firm and well-fitting splints until consolidation occurs. Wiesel records a successful case of ununited fracture of the ulna treated in this way.*

2. **Subcutaneous section,** consists in the introduction of a narrow-bladed knife or tenotome down the seat of fracture, and the free division of any fibrous union or false joint which may exist between the fragments. There is always a certain amount of danger in these cases of converting the simple into a compound fracture. Erichsen mentions such an occurrence as having happened in the practice of Liston, whereby much damage and suffering was incurred.

3. **Seton.**—The introduction of a seton between the ends of the fragments of a fractured bone is principally associated with the name of Physick, of Philadelphia, who strongly recommended it, and it was formerly largely adopted by surgeons in America. Physick used narrow tape, but silk and metallic wire have also been applied, introduced between the ends of the bone by means of a long seton needle. He recommended that the seton should be allowed to remain between the ends of the bone for a considerable time, even months, but in this he differs from the practice of other surgeons, who consider that sufficient action is induced in a few days, and that then it is better to remove it. The proceeding is not devoid of danger,

* *American Journal of Medical Science,* July, 1844 ; p. 254.

and may give rise to serious and even fatal results from diffuse inflammation, suppuration, or pyæmia.

4. **The introduction of ivory pegs.**—Perhaps there is no method of treating ununited fracture, which has been more advocated and more adopted than that which is generally known as "Dieffenbach's operation," which consists in the introduction of three or four ivory pegs into the ends of the fractured bone. The object is to excite inflammation in the neighbourhood of the fracture, and the irritation produced by the pegs appears to produce a large effusion of reparative material which consolidates the fracture. It appears to succeed better in ununited fractures of the upper extremity, especially the humerus, than in those of the lower, and in those cases where callus has been already thrown out, but has not ossified, rather than in those cases where a false joint has been formed.

The operation is best performed by first exposing the fracture, though some surgeons do not consider this necessary, but simply make punctures down to the bone. The bone is then drilled in different directions, and ivory pegs driven into the holes thus made. As the object is simply to excite inflammation there is no necessity to drive the peg accurately through each fragment, or to attempt to pin the ends of the bones together. The pegs after a few weeks may be removed. The operation is occasionally attended by fatal consequences.

5. **Drilling.**—Brainard, of Chicago, recommends perforating the fragments in two or three places with a strong metallic perforator so as to irritate the ends of the bones. He employs this method especially in very oblique fractures, or where there is overlapping. The perforator is introduced through the skin and made to transfix the bones. It is then withdrawn from the bones, but not from the skin, and

reintroduced through the former in another direction. This proceeding is repeated two or three times, or even oftener, and the ends of the bone and any intervening callus which may exist between them perforated in every direction through a single puncture in the skin. The proceeding possesses the advantage of being comparatively harmless.

6. **Pinning.**—Bickersteth, of Liverpool, has recommended pinning the ends of the bone together, either with copper nails or by leaving the ordinary drill-head *in situ* after it has been made to perforate both fragments. This holds the broken ends in position, while the irritation produced causes the formation of new bone. He has recorded some cases in which the result has been most satisfactory. In one case of oblique ununited fracture of the femur, in which I adopted this method, the result was not good; considerable suppuration took place on the withdrawal of the drill-head, and no union ensued.

Removal of the false joint may be performed by cutting down upon it and scraping or resecting the ends of the bone. Some surgeons have recommended the destruction of the articulation with caustics, but the method is uncertain and appears to possess no advantages over resection so that it has been abandoned by surgeons of the present day. Resection of the ends of the bone is also preferable to simply scraping their surfaces, as likely to lead to more certain results, and not in all probability being attended by any greater danger.

The operation was first advocated and performed by White, of Manchester, in 1760, but was subsequently opposed by Brodie and Malgaigne as involving too great danger from suppuration, osteo-myelitis and pyæmia. In the present day, however, with strict antiseptic precautions, the operation is undertaken with confidence, and appears in old and chronic cases

to hold out the best prospects of success. In a patient on whom I performed this operation for an ununited fracture of the femur, the wound entirely healed in five days, and consolidation of the fracture rapidly took place. Sometimes it is desirable, after the ends of the bones have been sawn off, to wire them together with a metallic suture, especially if there is any tendency in the fragments to become displaced, or any difficulty in maintaining them in strict apposition. Often, however, this is not necessary, the ends of the bones may be placed in position and the limb put up in splints and the case treated as one of ordinary compound fracture. Obviously it is better to avoid suturing the fragments together, as the sutures will act as foreign bodies, may prevent union, and will usually require removal in about two or three weeks. The necessary manipulation for removal being prejudicial to the well-doing of the fracture, liable to set up some fresh irritation and perhaps cause disunion of the still softly-united bones.*

Professor Nussbaum, of Munich, has recently recommended "transplantation of bone" in cases of ununited fracture where there has been loss of bone, generally the result of gun-shot injuries. It consists essentially in stripping a shell of bone and periosteum from off the adjacent bone and turning it down into the gap left between the fractured ends, care being taken to retain its periosteal connections with the shaft of the bone. In the case of a young officer with an ununited fracture of the ulna, this operation was performed and perfect union obtained.

In reviewing these different plans of treatment it would appear that the simplest and safest plan is that recommended by Brainard, of perforating the

* For a simple method of removing silver wire, when employed in cases of ununited fracture, *see* a paper by Mr. Francis Mason; Med.-Chir. Trans., vol. liv., p. 313.

fragments with a drill, which may, if the surgeon chooses, be allowed to remain *in situ* to pin the fragments together, as proposed by Bickersteth. Dieffenbach's operation is perhaps the one which is oftenest advocated, and may be tried, but is not altogether devoid of danger. If these should fail to accomplish union the most satisfactory results will be obtained by at once cutting down and resecting the fragments.

Section II.

SPECIAL FRACTURES.

CHAPTER I.

FRACTURES OF THE BONES OF THE FACE AND NECK.

Fracture of the Nasal Bones.

The nasal bones are always fractured by direct violence, such as a blow from the fist or a cricket-ball, or a kick from a horse, or by a fall against some prominent object, as a curb-stone or a door-step. The fracture is generally more or less transverse in direction, and usually occurs about half an inch from the free margin. The position, however, varies; when a great force is applied, as, for instance, a kick from a horse, the break may occur about the middle of the bone, and under these circumstances the fracture generally implicates the nasal process of the superior maxillary bone. When quite the upper part of the bone is broken, it is generally the result of some very severe injury, which fractures also the frontal bone and may be complicated with some injury to the brain.

In the ordinary fracture, near the free margin, displacement may or may not occur; when it does, the direction of the displacement depends very much on the direction of the blow, as there are no muscles which would have sufficient action on the fragments to draw them out of position. If the blow which produces the fracture descends straight upon

the nose, the lower fragments, together with the cartilaginous framework which they support, are driven directly backwards, producing flattening of the organ; but as a general rule it is found that the force is applied in an oblique direction; under these circumstances the fragments of bone are deflected to the opposite side as well as depressed, thus producing a still greater deformity.

The position of the displaced fragments is well shown in a specimen, in the Hunterian Museum, of a united fracture of the nasal bones.* The fracture has been a transverse one about half an inch above the free margin, and the separated fragments are driven inwards, and to one side, and united in this position. The displacement is not great, but must have driven the cartilages of the nose considerably to one side of the median line, and must have produced great deformity.

The **symptoms** by which fracture of the nasal bones are to be recognised are well marked, but at the same time the injury is one which is very liable to be overlooked, unless the case is seen immediately after the accident, since very great swelling from extravasation of blood almost always occurs, and is likely to mask the other signs, unless especial care be bestowed upon the examination.

The nose presents the appearance of flattening, and is often noticed to be deflected to one side of the middle line; and before swelling has come on, the sharp upper margin of the fracture can sometimes be felt prominently under the skin. After swelling has supervened, these symptoms are masked in the general deformity, and the surgeon will then have to trust to the sensation of crepitus in arriving at a diagnosis. This may generally be elicited by grasping the nose, and gently moving it from side to side. It ought,

* No. 878.

however, not to be forgotten that the nose is remarkably sensitive, and that this proceeding may cause the patient considerable pain; nevertheless, it is absolutely necessary that it should be done, in order to arrive at a correct opinion as to the nature of the injury.

The third great symptom of fracture, increased mobility, cannot be relied on in these cases as a means of diagnosis. The cartilages of the nose are so elastic and so movable on the bones, that the surgeon might easily fall into error if he trusted to this sign.

The **complications** which may arise in these cases are: (1) brain symptoms; (2) epistaxis; (3) emphysema.

The brain symptoms only occur in those cases, alluded to above, where the fracture is close to the root of the nasal bone, and is complicated with fracture of the frontal bone, and perhaps of the cribriform plate of the ethmoid, so that the patient is in danger from the injury done to the base of the skull, and the fracture of the nasal bones is of secondary importance. Of course, the same injury which produces the fracture of these bones may cause also concussion of the brain; but the one lesion has no connection with the other, beyond being produced by the same cause.

Epistaxis is an important complication of fracture of the nasal bones, since it may lead to an error in diagnosis.

Bleeding at the nose is a common symptom of fracture of the anterior fossa of the base of the skull, and one on which we rely in forming our diagnosis; but in these cases it is continuous and profuse, while the bleeding from a broken nose, though it may be profuse for a short time, rarely continues for long, but is soon arrested. In most cases also of fracture of the base of the skull the nose is uninjured, when the question of determining between these two forms of injury would scarcely arise.

Emphysema is an occasional complication of fracture of the nasal bones. The air in the nostril finding its way through the lacerated mucous surface, between the broken bones, and then diffusing itself through the subcutaneous cellular tissue in the region of the nose. It is, however, rarely extensive, and is a matter of comparatively little importance.

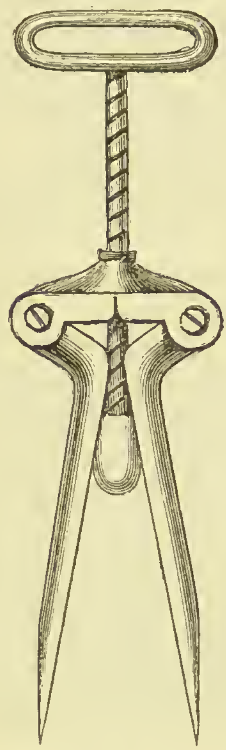


Fig. 11.—Screw Gag for elevating depressed Nasal Bones.

The gag is to be introduced into the nostril with the blades closed; by turning the screw the depressed bone can then be elevated into position.

The early recognition of fracture of the nasal bones is of importance, since on account of their vascularity they unite with great rapidity, a fact which has been known since the days of Hippocrates. Therefore prompt measures should be taken to restore the bones to their proper position. In order to effect a reduction it is generally desirable, especially in women and children, to administer an anæsthetic, since the nose is very sensitive, and it is essential that the patient should remain perfectly quiet during the operation. The depressed bone must be prized into its position by means of some instrument introduced into the nostril, at the same time the fingers on the outside of the nose must assist in guiding the bone into its proper place. A steel director will generally be found to be all that is necessary for effecting

reduction; but if there is any difficulty, a modification of an ordinary screw gag may be employed with advantage. The blades of the instrument should be made of about half an inch in width, and bevelled at the extremities (Fig. 11). The instrument is introduced into the nostrils closed, the wedge-shaped extremity being easily inserted beneath the depressed fragment. By turning the screw the blades expand, and raise the bone into its proper position.

When once replaced, if the fracture is single, and the septum not much altered in position, the broken bones will remain *in situ*; but in some complicated cases, and where the fracture is a multiple one, there is a tendency in the fragments to become again displaced. The surgeon must then endeavour to retain them in position by some substance introduced into the nostril. Of these, perhaps, the best and simplest is a number of small pieces of lint, smeared with vaseline, and introduced one after another into the nostril with a director; but, as Mr. Holmes Coote justly observes, "plugging the nostril should not be resorted to except in cases of severe misplacement, for it causes the patient great discomfort, and not uncommonly fails to effect the purpose for which it is used."

Some surgeons recommend small pieces of gum elastic catheter, encased in a drainage tube.

Mr. Adams employs a steel screw compressor as a retentive apparatus, which is to be worn for two or three days and nights without removal, and then replaced by an ivory plug.*

Mr. Erichsen recommends a vulcanised india-rubber bag, which is to be introduced empty, and then distended with water.†

And Mr. Holmes states that in a case under his

* *Lancet*, vol. i., p. 649; 1875.

† "Science and Art of Surgery," vol. i., p. 396.

care he obtained very good results by the use of a frame adapted to the head, and carrying two flat plates, something like the blades of a pair of flat forceps, between which the nose was kept evenly and comfortably supported for about three weeks, till all tendency to lateral displacement had disappeared.*

Fracture of the upper and bony portion of the septum nasi sometimes occurs, but when a solution of continuity of this part takes place, it is generally the cartilaginous septum which is broken, close to its point of junction with the bony portion. Possibly the injury may be a disunion of the two structures from each other. Of course, in all cases of fracture of the nasal bones, with much depression, the septum must also be injured to a certain extent; but occasionally cases are met with where the septum alone is involved, the injury not having been sufficiently great to cause fracture of the nasal bones. In these cases, when displacement occurs, it may be either laterally, or the septum may be depressed as well. In the former case, if the displacement is slight, there is little or no deformity in the outline of the nose, and the injury is very liable to be overlooked, especially as deviation of the septum is of common occurrence. If the displacement is very considerable, lateral obliquity of the lower part of the nose will result, and in consequence of the approximation of the septum to the outer wall of the nose, a certain amount of obstruction to the passage of air and nasal intonation result. When the septum is depressed as well as deflected, a very unsightly deformity is produced. The tip of the nose is turned upwards, while the bridge of the nose at the point of fracture presents a well-marked depression.

The treatment in these cases of fracture of the septum must be conducted on the same principle as in treating fractures of the nasal bones. The displaced

* "Principles and Practice of Surgery," p. 172. 3rd edit.

fragment must be gently raised or pressed back into its normal position, and retained there by means of pledgets of oiled lint, introduced alternately into either nostril, so as to make even pressure. A carefully moulded guttapercha splint applied to the outer surface of the nose is also occasionally necessary in those cases where the septum has been much depressed, in order to maintain the parts in position and prevent the tilting upwards of the end of the nose.

FRACTURE OF THE LACHRYMAL BONES.

The lachrymal bone is occasionally broken in conjunction with the nasal bones; the line of fracture running across the middle of the nasal bones, the nasal process of the superior maxilla and the lachrymal bone, possibly implicating the os planum of the ethmoid. This injury is always produced by great violence, and may be complicated with fracture of the anterior fossa of the base of the skull, and injury to the brain. In these cases the lachrymal apparatus is liable to be torn, causing obstruction of the nasal duct and overflow of the tears. The fracture is also liable to be followed by extensive emphysema. Upon the patient attempting to blow his nose, the air is forced outwards between the broken fragments, and widely diffuses itself in the cellular tissue of the eyelids, face and forehead.

FRACTURE OF THE SUPERIOR MAXILLA.

Fractures of the superior maxillary bone are generally the result of severe violence. They are always occasioned by direct force, such as a fall from a height on the face, or a severe blow, as from machinery in motion or a kick from a horse.

They may vary much in degree, from a simple chipping off of a portion of the alveolar arch to an extensive comminution of the whole bone.

When a portion of the alveolar arch is broken off (an accident which formerly occurred frequently when the "key" instrument was used for the extraction of teeth) it is usually depressed backwards, causing irregularity of the teeth, and great inconvenience from inability to masticate. There is often great difficulty in these cases in maintaining the displaced bone in position after reduction, and it is necessary to have a gold plate accurately fitted to the mouth, which can be worn until union has taken place.*

Transverse fracture occasionally occurs across the upper part of the superior maxillary bone.† This may or may not be accompanied by displacement. M. Guerin states that they frequently extend to the vertical plate of the palate bone and pterygoid process of the sphenoid, and that in these cases crepitus may be felt by pressing against the hamular process.‡ The other symptoms are fixed pain in the part, increased mobility in the lower part of the bone, extensive ecchymosis, and inability to masticate.

Fracture of the nasal process may take place as a complication of fracture of the nasal bones, and may involve laceration of the lachrymal apparatus.

Fracture of the anterior wall of the antrum sometimes occurs, producing great deformity from the depression of the fragments and sinking of the malar bone. The deformity can generally be overcome by introducing the thumb into the mouth and pushing the malar bone upwards and backwards.

Should this fail, Hamilton recommends that an incision should be made on the cheek at the anterior border of the masseter muscle and a strong blunt hook pushed under the bone, by which it may be dragged into its place.

* *See* a case by Mr. Salter; *Lancet*, vol. i., p. 593; 1860.
† *See* a case by Mr. Hutchinson; *Med. Circ.*, Feb., 1867.
‡ *Archives Générale de Médicine*, July, 1866.

Sometimes the whole bone is extensively comminuted, as in a case related by South, where a man was struck on the face by the handle of a revolving crane, and where the bones were so extensively comminuted as to "feel like beans in a bag."

In these cases the fracture is generally complicated with other injuries and terminates fatally. When death does not occur, on account of the great vascularity of the bones union readily takes place. The displacement of the fragments, however, produces great distortion of the features, and the amount of the deformity is often very distressing. All surgeons are agreed that on no account should any attempt be made to remove loose fragments, however slightly connected they may be. They ought in all cases to be most carefully preserved, and will probably unite and produce less deformity than if they had been removed. Cases of separation of the two maxillæ have been recorded by different authors.*

In many cases of fracture of the upper jaw, involving the alveolar process, the teeth may be loosened, but on that account should never be removed, as they will probably become firmly connected again. It may chance also that the tooth is not loosened in its socket, but appears to be so from the movement of the fragment to which it is connected. Hamilton records a case in which, in an attempt to remove an apparently loosened molar tooth, he brought away several teeth and the whole of the floor of the antrum.

Hæmorrhage is sometimes an important complication of fractures of the superior maxillary bone, the bleeding generally coming from some of the terminal branches of the internal maxillary artery which traverse the bone and are lacerated by the

* *See* cases by Dr. Harris; *New York Journ. Med.*, vol. xiii., 2nd Ser., p. 214; and Dr. Wilbur, *Amer. Journ. Med. Sciences*, April, 1873.

fracture. It must be arrested by cold, the application of styptics, and pressure. Secondary hæmorrhage is especially liable to occur in these cases, no doubt from the fact that the lacerated vessels are contained in rigid bony canals, and may lead to a fatal issue. In some of these cases ligature of the carotid artery has been resorted to, but without any satisfactory result.

The infraorbital nerve is also generally injured in cases of fractures of the superior maxillary bone, giving rise to numbness, and it may be permanent loss of sensation in the parts supplied by this nerve.

Fracture of the Malar Bone.

Simple uncomplicated fracture of the malar bone rarely occurs. Indeed, Hamilton states that he has been "unable to find any record of a simple fracture of the malar bone; that is to say, of a fracture unconnected with a fracture of other bones of the face." When any severe force is applied to the malar bone, as a blow or fall upon it, it does not, as a rule, give way, but the force of the blow crushes in the thin anterior wall of the antrum and displaces the malar bone, which rests upon it and derives its support from it, without causing any fracture to the bone itself. This has already been alluded to as one of the forms of fracture of the superior maxillary bone. Occasionally fractures of the orbital surface may occur, or a portion of the orbital margin may be chipped of. These cases are of interest, inasmuch as they are liable to lead to an error in diagnosis. The fracture is attended with extravasation of blood into the orbit, which exactly resembles that which occurs from a fracture of the base of the skull.*

If a greater degree of force is applied to the bone than is sufficient to produce either of the two fractures enumerated above, that is to say, fracture of the

* *See* a case by Mr. Holmes; *Brit. Med. Journal*, p. 967; 1855.

anterior wall of the antrum and depression of the malar bone, or fracture of the orbital plate, it will generally cause fracture not only of the malar, but also of the other bones of the face. And a fracture of this bone would imply multiple fractures of the facial bones. Under these circumstances the fractured portion of the malar bone may be displaced inwards, producing great deformity and possibly protrusion of the eye-ball. This protrusion may, however, be caused simply by extravasated blood, and therefore be only temporary.

If there is simply a fissure through the orbital surface the injury may very probably be overlooked, and this is of the less importance as surgical interference is not necessary. If the bone, however, is depressed or displaced, an attempt should be made to restore it to its normal position, by the means described under fractures of the superior maxillary bone, otherwise a distressing deformity will result.

Fracture of the Zygomatic Arch.

Fracture of the zygomatic arch is a much rarer injury than might be expected, from its somewhat exposed position. The form of the arch, and its being strengthened by the thick temporal aponeurosis above and the fleshy and tendinous fibres of the masseter muscle below, protect it from injury, so that fracture of the bone is a rare injury in surgical practice.

There are three different ways in which this fracture may be caused: (1) by direct violence; (2) by indirect violence, when the malar bone has been depressed in fractures of the anterior wall of the antrum; and (3) by foreign bodies thrust through the mouth against the zygoma.

The displacement which occurs in these cases is therefore either inwards or outwards; the displacement upwards or downwards being prevented by the attachments of the temporal aponeurosis and the

masseter muscle; though it is said by some that the action of this muscle may produce displacement of the fragments downwards. The *inward* displacement generally occurs when the fracture is produced by a direct blow on the zygoma. The *outward* displacement in fractures from indirect violence, or when the force has been directed from within outwards.

These fractures are always attended by very considerable swelling and ecchymosis, so as to obscure the other symptoms. These are, the history of the accident, pain, and possibly crepitus, especially if the fracture is comminuted. If the case is seen before swelling comes on the irregularity in the zygomatic arch is readily perceived, and the diagnosis at once established, but in the majority of cases the swelling is so great that the continuity of the arch cannot be traced. There is in these cases difficulty and even inability to open and shut the mouth. This has been asserted to be due to the displaced fragments perforating the temporal muscle, and this accident is usually quoted in our text-books as one of the complications of fracture of the zygoma. It must be remembered, however, that a considerable mass of fat separates the bone from the muscle, and that, moreover, it is the tendon, and not the muscular fibres, which corresponds to the level of the arch, so that it would require very great displacement and considerable force to produce this accident, and except in some cases of comminuted fracture, when a splinter of bone may perchance perforate the tendon, it is not very likely to occur. One cause which may assist in preventing the movements of the lower jaw may be perhaps the impaired movements of the masseter muscle, from its bony origin having been injured.

In the treatment of these fractures, an attempt must be made, if possible, to restore the proper position of the arch. If the fracture has been produced from indirect violence, from a blow on the malar bone, the

means which have been recommended above, for restoring this bone to its natural position, will generally succeed in effecting a restoration of the normal position of the arch, assisted by pressure upon the projecting bone. But if the fragments have been displaced inwards, surgical interference is rarely required or justifiable, beyond an attempt, under anæsthesia, and pressure from within the mouth, by gentle manipulation to restore the fragments to their proper position. It has been recommended in these cases to make an incision down to the bone, and perforate it with a screw elevator, and thus endeavour to raise the fragment; or else, by making an incision through the temporal fascia to introduce an elevator behind the fractured bone, and thus raise it into position.

Such proceedings are, however, scarcely justifiable, since the depressed bone appears to produce little or no inconvenience, and the operative proceeding must convert the simple into a compound fracture. For, even in those rare cases in which the tendon of the temporal muscle may have been injured, Hamilton states, "that the points are gradually absorbed and rounded, so that after a time they constitute no impediment to the action of the muscle."

Fracture of the Inferior Maxillary Bone.

The inferior maxilla is by far the most frequently fractured of all the bones of the face. This is no doubt due to its exposed situation, and its liability to injury; and probably fracture of this bone would be still more common, if it were not for its shape, in the form of an arch, which imparts additional strength to the body of the bone, and also from the dense and compact nature of its bony structure, which enables it to resist great force.

The body of the bone is much more frequently

fractured than the ramus. This is partly on account of the body being more exposed to injury than the ramus; partly because the latter is protected by the thick muscles which cover it on either side. Fracture may occur at any part of the body; the most common situation is stated to be in the neighbourhood of the canine tooth, and this is explained by the greater weakness of the bone at this point, since it is hollowed out to a great extent to admit of the long fang of this tooth. The position of the mental foramen seems also sometimes to determine the line of fracture, since Hamilton found it, in fourteen out of twenty cases of fracture of the body of the bone, in this situation. Fracture at or near the symphysis also not unfrequently occurs. Some surgeons believe that this fracture actually occurs at the sutural line, even in those who are too old to allow of the separation of the two portions of the bone before complete fusion has taken place. Others assert that the fracture never occurs exactly at the symphysis, but always to one side of the median line.

When the ramus of the bone is the seat of the lesion, the *angle* may be the part fractured; or the *neck of the condyle* may be broken off; and lastly, in some rare instances, the *coronoid process* has been fractured by extreme violence. The fracture through the neck of the condyle is generally oblique in direction, though transverse fracture may occur, as in a case figured in Sir William Fergusson's "Practical Surgery." The fracture of the coronoid process, when it occurs, is also oblique in direction, running downwards and forwards from the middle of the sigmoid notch.

Fractures through the body of the bone are usually oblique in an antero-posterior direction; that is to say, the fracture travels through the thickness of the bone, in such a direction that the posterior fragment

has a tendency to override the anterior. Malgaigne states that he has only been able to find two cases where the obliquity was in the opposite direction.* Dr. Kinloch records a third case, where the lower jaw was fractured in front of the anterior border of the masseter muscle. The line of fracture divided the bone obliquely through its thickness, the obliquity being at the expense of the external plate of the smaller external fragment, and of the internal plate of the larger or anterior fragment † (Fig. 12).

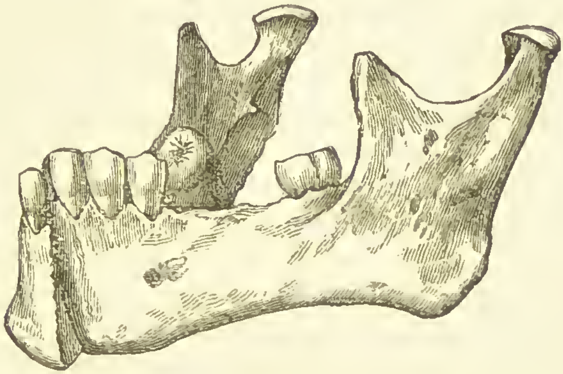


Fig. 12.—Fracture of the Inferior Maxillary Bone.

The fracture has taken place a little external to the symphysis, and is oblique in direction from before backwards. The larger fragment is somewhat depressed, and lies in front of the smaller fragment.

Multiple fracture is perhaps more common in the lower jaw than in any other bone in the body, for it not unfrequently happens that a fracture takes place on either side of the symphysis. These may be symmetrical, but what usually occurs is for fracture to take place through the body on one side and the ramus, at or near the angle on the other.

Fractures of the lower jaw are peculiar in one respect, and that is, that they are for the most part

* "Traité des Fractures," p. 381.

† *Amer. Journal of the Med. Sciences*, July, 1859; p. 67.

compound. The muco-periosteum, covering the alveolar process, is torn through and the fracture communicates with the air in the cavity of the mouth. In spite of this, these fractures, for the most part, unite in the same manner as an ordinary simple facture.

Causes.—The most common cause of fracture of the lower jaw is direct violence; blows on the jaw in fighting, or from a club; a kick from a horse or a fall from a height, are among the most frequent causes of this injury. The fracture may occur from indirect violence, as when the bone is compressed at its angle, generally from a carriage wheel passing over it, and gives way at or near the symphysis. Gun-shot wounds also produce some of its most serious forms, the fracture then being compound and generally comminuted. Cases are also recorded in which muscular action is said to have caused it. Fracture of the ramus in the neighbourhood of the angle always appears to be produced by some direct violence applied to the part. But the neck of the condyle may be fractured either by direct or indirect force, more commonly the latter; for, in the large majority of cases, the accident has been caused by falls from a height on the chin; though instances have been recorded where the accident has been produced by a violent blow on the side of the face. Fracture of the coronoid process can only occur from a severe blow directly on the part, and is generally the result of a gun-shot injury, or of a fall from a height, in which multiple fractures are produced, as in a case recorded by Honzelot, in which there was a fracture of both condyles, of the symphysis, and of both coronoid processes.*

Symptoms.—The symptoms of fracture of the lower jaw are sufficiently well marked to avoid, as a rule, any error in the diagnosis. They comprise all of the ordinary symptoms of fracture, viz. pain, deformity,

* Malgaigne, "Traité des Fractures et des Luxations," p. 400.

increased mobility in the continuity of the bone, and crepitus. To these signs we may add bleeding and laceration of the gums and dribbling of the saliva. The position of the patient is also characteristic; he will be noticed to support the jaw with his hand, especially upon making any attempt at articulation or swallowing. The pain complained of is usually very severe; much more so, in fact, than in most other fractures. This is probably due to the laceration of the soft parts, but may also, to a certain extent, be caused by some lesion of the inferior dental nerve or its branches. That more severe complications from injury to this nerve do not often follow fracture of the jaw has been the subject of frequent comment, since one can scarcely believe that in a fracture of the bone with considerable displacement complete rupture does not take place. Hamilton, however, appears to doubt it, and considers that the displacement is never so great as to cause complete laceration of the nerve; while Boyer, on the other hand, explains the infrequency of injury to the fact that fracture generally occurs anterior to the position of the mental foramen, and that, therefore, the main trunk of the nerve is not implicated. And if the statement made above is true, that fracture generally occurs at or about the position of the canine tooth, this hypothesis is correct. At the same time it must be a matter of almost universal observation that fractures occurring at the posterior part of the body of the bone do equally well, and present none of the symptoms which one would be inclined to expect from injury to the nerve. It is possible that if the nerve is only stretched, and not torn across, the symptoms may escape notice, since they would scarcely be observed during the period that the parts are kept covered with bandages; and by the time these are removed the nerve may be expected to have, at

all events to a certain extent, recovered its functions.

The deformity which is produced is due to the displacement of the fractured surfaces from each other, and this displacement can be readily made out by examining the line of the teeth in cases of fracture of the body of the bone occurring in front of the anterior border of the masseter muscle. When the fracture takes place behind this point, the masseter and internal pterygoid muscles remaining attached to both fragments of the bone retain them in position, and very little displacement takes place.

The displacement of the anterior fragment is downwards and inwards; that of the posterior fragment is outwards, so that it overrides or overlaps the larger anterior fragment. Occasionally, however, the position is reversed, and the posterior fragment lies within the other (Fig. 12). The reason of this is, that in all probability the obliquity of the line of fracture through the bone is also reversed, being at the expense of the outer plate of the posterior fragment and the inner plate of the anterior fragment.

The causes of the displacement appear to be two-fold. The downward displacement of the anterior fragment is probably entirely due to muscular action, the muscles passing from the neighbourhood of the symphysis of the jaw to the hyoid bone, viz. the digastric, the genio-hyoid, the anterior fibres of the genio-hyo-glossus, and possibly the mylo-hyoid have a tendency to pull this fragment downwards and a little backwards, while the posterior fragment is kept closely fixed against the teeth of the upper jaw by the action of the elevators, viz. the temporal, masseter, and internal pterygoid. Accordingly we find that when a double fracture has occurred, that is to say, a fracture through either side of the body, the displacement downwards is often very considerable, the depressors pulling the central piece downwards, the

antagonistic action of the elevators on both sides being destroyed. The lateral displacement would seem, in a great measure, to be due to the force which produced the injury and its direction, the posterior fragment being either inside or outside the anterior, according to the direction of the obliquity of the fracture. No doubt the masseter, and perhaps also the temporal muscle, have a tendency to draw the posterior fragment outwards, and at the same time a little forwards, thus assisting in determining the displacement. In fracture of the neck of the condyle the displacement is often very great, the condyle being drawn inwards and forwards by the action of the external pterygoid muscle; while, in consequence of the unbalanced action of the muscles of the two sides, the whole of the rest of the jaw bone is drawn over to the affected side. The displaced condyle can be readily felt by the finger introduced into the mouth. In fracture of the coronoid process, if the piece of bone is completely severed from the jaw, it is drawn upwards by the temporal muscle. Probably, in most cases, the displacement is very slight, since the bone is retained in its position by the fibres of the tendon of the temporal muscle which are prolonged downwards to be attached to the extremity of the mylo-hyoid ridge.

The mobility of the broken surfaces in fracture of the body of the jaw is not, as a rule, great, if the fracture is only on one side of the body of the bone; if it is on both sides the movement of the central fragment is sometimes considerable, and can be easily perceived upon any attempt of the patient to move his jaw. When the fracture is on one side only, the preternatural mobility may be ascertained by grasping the jaw with the fingers introduced into the mouth and moving the bone slightly upwards and downwards. This will probably elicit also a sensation of crepitus, and thus complete the diagnosis of the injury.

Complications.—The most common complication which arises in connection with fracture of the lower jaw is loosening and dislocation of the teeth. When they are simply loosened they should never be removed, as, in all probability (as the process of union goes on), they will become again firmly fixed in their sockets. There is one particular point in connection with dislocated teeth that requires to be borne in mind, namely, that the displaced tooth may become lodged between the broken ends of the bone, and thus interfere with the proper adaptation of the fragments, and, as in a case recorded by Mr. Erichsen, prevent union of the fracture. Hæmorrhage is not a common complication of fractured jaw, though it would seem remarkable that the inferior dental artery should escape injury in fractures implicating the canal in which it is situated. Like the nerve, however, it appears generally to escape laceration, and the bleeding from a fractured jaw is generally confined to slight oozing from the lacerated gums. The late Mr. Maunder records, however, a case in which severe hæmorrhage took place, and was only controlled by digital compression of the carotid artery.*

Necrosis is a not uncommon sequel to fractures of the jaw; leading to delayed union and abscess, the matter pointing below the jaw and sometimes burrowing down the neck. Generally the necrosis is slight in extent, and involves only the alveolar border, but occasionally it may implicate the whole thickness of the bone. The loss of bone is then considerable, and the resulting deformity great. This is well shown in a preparation in St. George's Hospital museum, where there has been a fracture situated on the right side of the symphysis. The fracture has united, but there has evidently been a considerable loss of substance and consequent deformity (Fig. 13).†

* *Lancet*, vol. ii., p. 2; Oct. 12, 1867.
† Series i.; prep. 38.

Mr. Holmes records in the Pathological Society's Transactions a curious complication of fracture of the neck of the condyle of the lower jaw.* The lower fragment of the fractured bone was displaced into the meatus auditorius, causing a partial separation of the cartilaginous from the osseous part of the tube. There

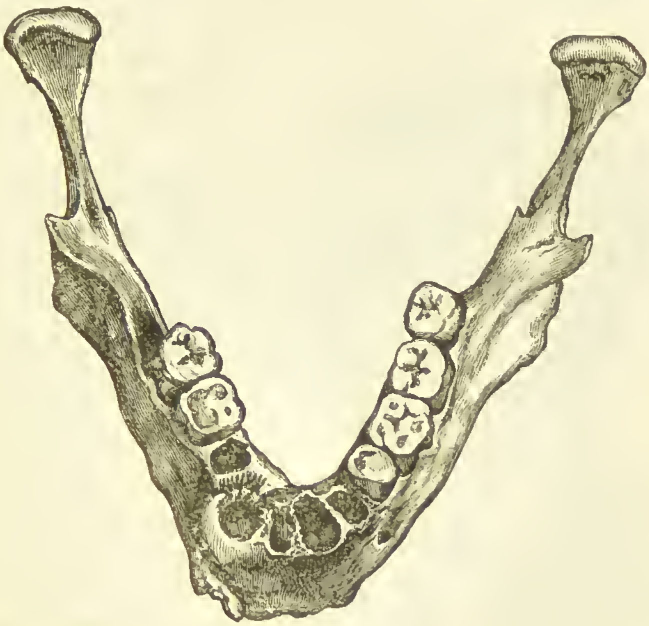


Fig. 13.—Union of Fracture of the Lower Jaw, with Deformity.

The fracture is situated to the right side of the symphysis. A loss of substance from necrosis has taken place, and union has resulted with considerable deformity. In the vicinity of the fracture the bone is much thickened, and there are small bony outgrowths in the neighbourhood. (From a preparation in the museum of St. George's Hospital, series i., 38.)

was a copious discharge of serous fluid, simulating the discharge which occurs in fracture of base of skull.

Treatment.—Most cases of fracture of the lower jaw do well with comparatively little treatment; but then, on the other hand, it must be stated that occasionally cases are met with which seem to baffle

* Path. Soc. Trans., vol. xii., p. 159. The preparation is in St. George's Hospital museum, series i., prep. 40.

all the efforts of the surgeon to maintain the fragments in good apposition and to bring to a satisfactory conclusion. Hence a large number of different plans have been advocated for dealing with these cases, and different forms of splint have been introduced for keeping the fractured surfaces in position, all of which, no doubt, are more or less useful; but it will nevertheless be found that cases sometimes arise in which, in spite of the utmost endeavours of the surgeon and the most carefully contrived appliances, faulty union will result.

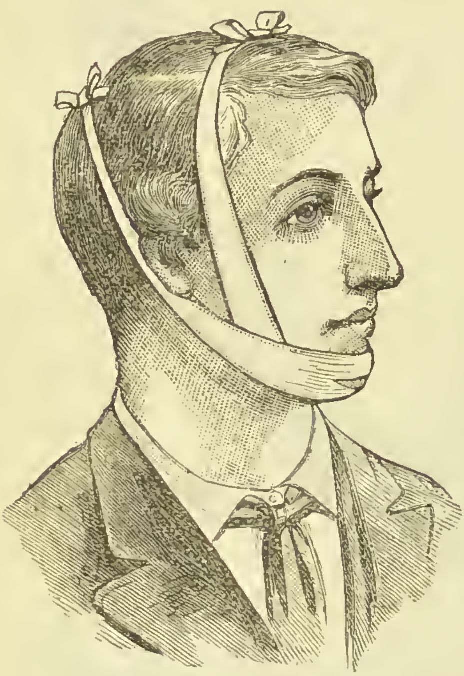


Fig. 14.—Bandage for Fractured Jaw.

The figure shows the manner of applying the four-tailed bandage in fracture of the lower jaw.

In the majority of cases of simple uncomplicated fracture, there will be found to be no difficulty in replacing the fragments by proper manipulation, and in retaining them there by means of a bandage, with or without a moulded splint. This is the simplest form of appliance, and as efficient as it is simple. After the fracture has been reduced, a piece of bandage, about a yard in length and four inches in width, with a small hole in the centre, and with the ends split to within about four inches of the hole, is to be applied to the jaw in such a manner that the point of the chin is

received into the hole. The two lower strands of the split portion are then tied over the vertex and the two upper ones behind the occiput, and to prevent them slipping the two pairs of strands may be tied together (Fig. 14). By this bandage the teeth of the lower jaw are brought into close apposition with those of the upper, which thus act as a splint, and serve to fix them in their proper position. Hamilton has objected to this plan on account of the tendency which he says it has to pull the anterior fragment backwards, and

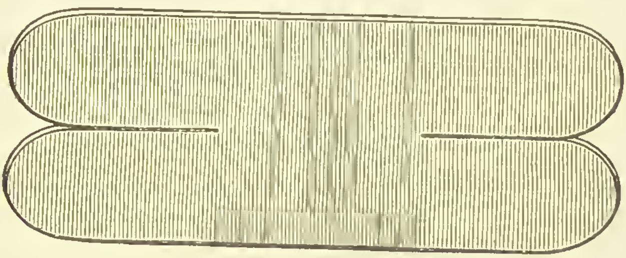


Fig. 15.—Splint for Fracture of the Lower Jaw.

A piece of guttapercha cut into the proper shape for applying in a case of fracture of the lower jaw.

has devised a somewhat more complicated bandage in order to obviate this difficulty.* The reason why this backward displacement occurs is because surgeons are wont to recommend that the upper strand of the bandage should be tied round the nape of the neck. This has a tendency to pull the anterior fragment directly backwards, but if the bandage is applied as above directed, and as it is shown in the figure, this displacement will not occur.

Some surgeons recommend, in addition to the above four-tailed bandage, the application of a moulded splint of guttapercha or pasteboard. But it should not be employed if it can be avoided, for it is

* The bandage is described and figured in his work, "Fractures and Dislocations," p. 131.

uncomfortable to the patient from retaining the perspiration,* often becomes dirty and sodden from the dribbling of saliva, and if there is any bruising or injury to the soft parts may, by the pressure which it causes, produce suppuration. The material, of which guttapercha is to be preferred on account of its greater cleanliness, is to be cut in the shape depicted in the figure (Fig. 15), and having been softened in hot water is to be moulded to the chin, the sides being folded around and below the bone as shown in Fig. 16. After it has become hardened, it must be taken off, properly lined with lint, and then refixed with a four-tailed bandage.

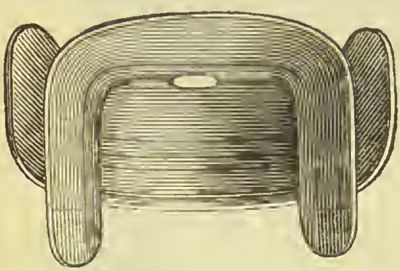


Fig. 16.—Splint for Fracture of the Lower Jaw.

The same piece of guttapercha as in Fig. 15, moulded into a splint, ready for application in a case of fracture of the lower jaw.

Whether the moulded splint is used or not, it will be seen that the efficiency of the treatment depends upon keeping the teeth of the two jaws in apposition, so that the patient cannot open his mouth. He will, therefore, have to be fed entirely on fluid nourishment, which he can suck in between his teeth and through the gap which exists behind the last molar. The mouth should be syringed frequently with a weak solution of Condy's fluid, and all attempts at speaking prohibited, the patient being supplied with a slate on which he can make known his wants.

Fractures of the jaw, as a rule, unite readily, so that at the end of the third week a little liberty may be allowed, and the patient may be permitted to open

* It is sometimes recommended that holes should be drilled in it to allow of evaporation.

his mouth sufficiently to permit of the introduction of soft food, but all attempts at mastication must be interdicted till the end of the fifth week, when a fairly secure union may be anticipated, and the bandage dispensed with. It is advisable, however, that the patient should still wear a handkerchief or piece of riband round the chin and tied over the top of the head, especially at night, in order to check too violent movement of the jaw.

In some complicated cases, this simple plan of treatment will not be sufficient, and the surgeon will then have to tax his ingenuity to obtain a satisfactory result, in some cases employing one of the numerous mechanical appliances which have been devised; in other cases, another. Among these are those cases where the fracture is multiple, or where it is very oblique, or with great bevelling of the edges, in which it will be found very difficult to replace the broken bones and retain them in position. Recourse must then be had to one of the three following plans: (1) Ligaturing the teeth or wiring the fragments together; (2) some form of interdental splint; (3) a combination of an interdental splint with some external apparatus.

Undoubtedly the simplest proceeding is to tie the sound teeth together on either side of the fracture with strong silk or wire; it is not, however, a plan which can be recommended, and frequently leads to unsatisfactory results. It tends to loosen the teeth, and then the cord being slackened the displacement recurs. It frequently cuts and irritates the gums, and is a source of great discomfort to the patient; and it seldom secures complete immobility between the fragments. The plan of wiring the two pieces of bone together is far more satisfactory, but is also open to some objections. It has of late years been strongly advocated by Mr. Hugh Thomas, of Liverpool, who

relates two cases in which he obtained most satisfactory results.*

Mr. Weellhouse, of Leeds, has somewhat modified this plan by inserting two silver pins through the jaw from behind forwards, one on either side of the fracture. The pins are perforated at their head, and through the perforation a stout silk ligature is passed, brought forwards over the teeth, and then twisted in a figure of 8 manner round the anterior extremities of the pins, which are bent in opposite directions, away from the fracture.†

Dr. E. T. Fountain records a case of fracture of the neck of the condyle of the lower jaw, in which, after failure by many other methods, he at last succeeded in retaining the bone in position by drilling a hole in one of the incisor teeth of upper and lower jaw, and wiring the superior and inferior maxillary bones together.‡

Of the various forms of interdental splints, the one invented by Mr. G. E. Hammond is the most satisfactory, both on account of its easy application, and because it is thoroughly efficient in the vast majority of cases, though there are a few in which it is not applicable. The splint consists of a framework or collar of iron, which is adapted to the fractured jaw, encircling the necks of the teeth, and to it they are fastened by loops of iron wire. The essential point in the application of the splint is that the collar of iron wire should accurately fit the outline of the jaw, so that it shall remain in the position in which it is placed, otherwise it will probably defeat the object for which it is intended. In order, therefore, to frame it, it is necessary to take a cast of the

* *Lancet*, vol. i., p. 79; 1867. *See* a case also recorded by Mr. Chauncy Puzey; *Lancet*, vol. ii., p. 327; 1876.

† *Lancet*, vol. ii., p. 195; 1867.

‡ *New York Journal of Medicine*, Jan., 1860.

teeth on which to model the collar, and it is not sufficient, as is recommended by some authors, to apply a circle of wire to the teeth and adjust it with a pair of small curved pliers. When moulded it will present somewhat the outline represented in the figure (Fig. 17), copied by permission from Mr. Heath's work.* The collar is to be applied to the teeth of the patient, and fixed in the manner shown in the diagram by several pieces of fine, soft wire, the wire being never carried round more than one tooth. The wires on each side of the mouth are twisted alternately, and the twisted ends are cut short and turned down under the iron framework, so as to prevent their sticking into or injuring the mucous membrane of the lip.

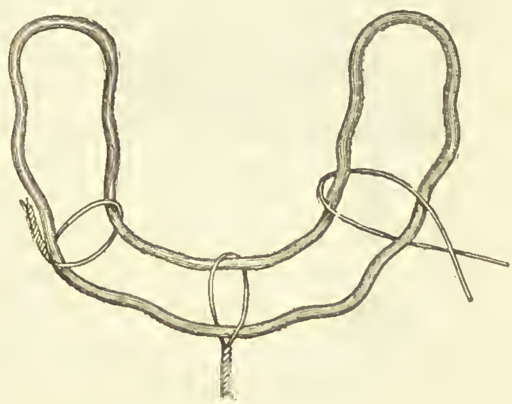


Fig. 17.—Hammond's Splint for Fracture of the Lower Jaw.

The figure shows the collar of metal moulded to fit the teeth of the lower jaw, and the manner of tying the teeth to the metal collar.

There are some cases, however, where this splint is not applicable, that is to say, in fractures very far back; where sufficient hold cannot be obtained either from an absence or an undeveloped condition of the last molar tooth; or in the edentulous jaw.

Another form of interdental splint consists in a mould constructed of vulcanite; or, what is better, some metal, such as gold or silver, as it is more easily kept clean, and occupies very much less space in the mouth.

* "Injuries and Diseases of the Jaws."

Mr. Moore, of Guy's Hospital, employs a cap of "dental alloy."* This is retained in position by a vulcanite cap made to fit the upper teeth; on the surface of this is fixed a wedge, with its base in front, so that when the mouth is kept closed by a four-tailed bandage the wedge presses upon the metal cap and holds it in position over the fractured bone, while the mouth is kept sufficiently open to allow of the introduction of food.

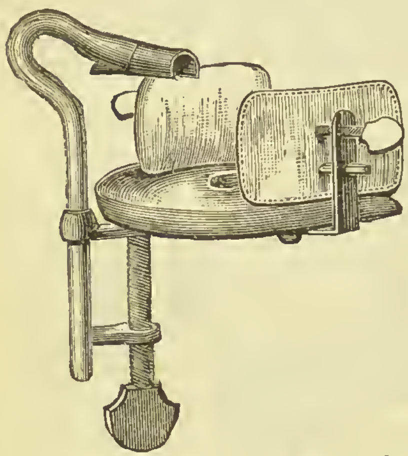


Fig. 18. — Lonsdale's Clamp for Fracture of the Lower Jaw.

The rod carrying the ivory cap is moved by the screw. The chin is placed on the chin piece and the cap is then adjusted to the incisor teeth by means of the screw. The two cheek-pieces are then made to press lightly on the jaw on each side to prevent the apparatus from becoming displaced.

Various combinations of interdental splints with some external appliance for maintaining it in position have been invented. Of these, perhaps the best known and the most frequently employed is the one invented by Lonsdale (Fig. 18). It is, however, only suited to fractures near the symphysis, as the ivory cap is too short to reach far along the arch of the teeth. Mr. Berkeley Hill has substituted a metal mould of the alveolar arch for the ivory cap, and has done away with the lateral pads.† Mr. Moore has further modified the appliance by making it in two halves, so that it will fit any jaw, and by attaching horizontal bars to the metal cap which pass out of the angles of the mouth, and are connected with the vertical bars attached to the chin piece.

* Guy's Hospital Reports, vol. xix., p. 179.
† *British Medical Journal*, vol. i., p. 22; 1867.

Mr. Howard Hayward employs a silver cap to fit the teeth; to this he solders two doubly-curved bars of silver, which pass out of the angles of the mouth and turn back over the cheek, and are firmly fixed to a chin splint made of guttapercha, and held in position by a four-tailed bandage.*

The main objection to the combination of the external and internal splint is the pressure which it is necessary to make on the chin in order to maintain the fragments in position, for this causes great pain, and may lead to ulceration or sloughing. In addition to this, Lonsdale's apparatus, or its modifications, is exceedingly cumbersome and irksome to the patient.

From what has been stated, it would appear that most cases of simple fracture may be treated by means of a four-tailed bandage, and require no other appliance. In severe cases, where there is a difficulty in maintaining the fragments in apposition, Hammond's wire splint will be found to be the most reliable appliance in the majority of instances, and is preferable to wiring the fragments together.†

But the surgeon must still be prepared to meet with a certain number of cases in which neither of these plans will succeed, and in order to prevent non-union or deformity, he will have to resort to one or other of the several methods enumerated, employing that one which seems to answer best in the particular case under observation.

Ununited fracture of the lower jaw is rarely met with. Norris found it in only two instances out of 150 cases of non-union of different bones. This is a fact worthy of note, and is the reverse of what might

* *British Medical Journal*, October, 1858; p. 845.

† Mr. Jacobson states, "This method has, since 1873, been entirely replaced at Guy's Hospital by the use of Mr. Hammond's splint."

have been expected; for, as Hamilton has pointed out, there is great difficulty in maintaining strict immobility of the fragments, especially during the act of deglutition. Nevertheless, fractures of the lower jaw unite well and quickly. The principal causes of non-union are the presence of a sequestrum or tooth between the fragments, or the movement of the broken ends one on the other. The result may be either imperfect, that is, fibrous, union, or a complete false joint, and the amount of inconvenience, as Mr. Heath has pointed out, will depend upon the situation of the fracture. If it is in the ramus, it will give little inconvenience, the false joint taking the place, and to a certain extent performing the functions, of the temporo-maxillary articulation. If it is in the body of the bone, there will be inability to masticate properly, the digestion will become impaired, and the health of the patient suffer.

Treatment.—The treatment of ununited fracture will depend on the cause. If any movement has been permitted between the fragments, the application of one of the appliances mentioned above, so as to maintain as perfect immobility of the fractured surfaces as is possible, will generally be all that is necessary. If the non-union is due to the presence of a piece of necrosed bone, the removal of this source of irritation will generally effect a speedy cure. Should, however, the case be one of old standing, in which a false joint has been fully developed, it will be necessary to expose the fracture and resect the fragments, or freshen their surfaces and fasten them together. Under these circumstances there is no objection to wiring them together, after the manner advocated by Mr. Thomas, of Liverpool, since the bone being exposed there is no difficulty in drilling the fragments, and the instrument can be introduced at a much lower level, so that all chance of injuring the teeth is avoided; or the plan

employed by Mr. Bickersteth, of fixing the fragments with copper nails, may be adopted.

Fracture of the Hyoid Bone.

Fracture of this bone is of rare occurrence,* but occasionally takes place, and gives rise in most cases to a well-marked train of symptoms.

The **causes** which may produce it are the common causes of fracture, namely, direct violence, indirect violence, or muscular action. By direct force, it may be produced by falling and striking the upper part of the neck against some prominent object, or by blows, or by hanging, though the observation of Mr. South, that this accident "almost invariably occurs in persons who are hanged," is not correct. Under these circumstances the body of the bone is generally broken. By indirect force the bone may be broken by grasping the throat, when it generally gives way at about the junction of the greater cornu and the body, or the former process is simply broken off. Cases where the fracture has been attributed to muscular contraction are very rare.

Sir Duncan Gibb states that in thirteen cases of fracture of the hyoid bone, where the bone had been broken from external violence, other than hanging, in seven cases it was produced by throttling; in three from direct injury; and in three from muscular action.†

The displacement which occurs in these cases is generally very great, and not infrequently the mucous membrane of the pharynx is lacerated by the displaced fragment, and copious hæmorrhage is the result.

* In a communication to the Pathological Society, Mr. Arbuthnot Lane states that he has seen nine instances of fracture of the hyoid bone or cartilages of the larynx out of 100 bodies examined by him in the dissecting room. This would tend to prove that these injuries are by no means so uncommon or so fatal as is generally supposed.—*Lancet,* vol. i., p. 429; 1885.

† Path. Soc. Trans., vol. xiii., p. 173.

Symptoms.—In most of the recorded cases a prominent symptom has been a sudden snap, producing a sensation as if a solid body were breaking, and accompanied by an acute pain. When the pharynx has been perforated, this has been followed by bleeding, sometimes profuse, from the mouth. There is difficulty and pain in moving the head, or in opening the mouth, and also in protruding the tongue. There is dysphagia, and in some instances total inability to swallow. The patient has great pain and difficulty in speaking, and the voice is hoarse or altogether lost. Upon examining the neck, there will generally be found to be swelling and ecchymosis. If the case is seen soon after the accident, before any great amount of swelling has come on, by gently grasping the bone between the finger and thumb and cautiously moving it from side to side, an irregularity in its outline may be perceived, and possibly crepitus may be felt. This sign, however, is usually absent, inasmuch as the displacement of the fractured portion is so great that it cannot be elicited. On examining the mouth, swelling and ecchymosis of the mucous membrane will not infrequently be perceived, and the broken end of the bones may be seen or felt projecting into the pharynx. Later on, dyspnœa, constant harassing cough, and expectoration may supervene.

Treatment.—An attempt must be made to restore the displaced fragment to its normal position by introducing the fore-finger of one hand into the mouth, and while the bone is supported by the other hand placed on the outside, gently pushing the bone back into its proper place. This can sometimes be accomplished with ease; in other cases the greatest amount of difficulty is experienced. After the replacement of the fragment, its maintenance there is extremely difficult, since no apparatus can be applied to retain the broken ends in apposition. The means to be adopted

are to prevent, as far as possible, any movements of the neck. The patient should be placed in a "bed-chair," with the head thrown slightly back, and fixed in this position by a coronal bandage and two braces passing to the shoulder on either side, as is employed in cases of cut throat. The neck should be encircled by a collar made of soft chamois leather spread with adhesive plaister, which should be carefully applied, so as to lie evenly, but at the same time not constrict the neck.* All attempts to speak should be absolutely forbidden, and it is better for the first few days to feed the patient entirely by nutrient enemata; after which he may begin to take fluid food. If great difficulty in breathing should come on, laryngotomy must be performed.

Fracture of the Cartilages of the Larynx.

The cartilages of the larynx are usually broken by direct violence, as a kick from a horse, a severe blow, or a fall against some projecting object. They may also, especially the thyroid, be fractured by being violently grasped by the hand of an adversary, or in hanging. The injury is generally found to occur in advanced life, after the cartilages have undergone a certain amount of ossific change, but it occasionally occurs in young persons, and even in children.

The accident is always a dangerous one, and frequently terminates fatally.

According to Mr. Durham, fifty-three cases out of a total of sixty-nine ended in death.† And Fischer, out of a total of seventy-five cases, gives fifty-nine deaths. This large mortality is due to the displaced fragments encroaching on the air passage and obstructing the respiration.

* Mr. Erichsen recommends a stiff pasteboard collar to prevent displacement.

† "System of Surgery," vol. i., p. 749.

Symptoms.—The patient complains of great pain following an accident or injury in this region; the pain being much increased by attempting to swallow or speak. There is swelling and ecchymosis of the neck, and if the mucous membrane of the larynx has been lacerated, emphysema. There is constant cough, and it may be bloody expectoration, and great difficulty in breathing, with lividity of the face. Upon examination of the neck, a distinct displacement of the cartilages may be detected; sometimes there is increased prominence of the pomum Adami; at others undue flattening. Sometimes crepitus and increased mobility of the fragments may be detected.

Treatment.—In simple, uncomplicated fractures, where there is no great difficulty in breathing, little requires to be done. But as in the majority of cases there is more or less impediment to respiration, produced sometimes by the displaced cartilage, at others by submucous extravasation of blood, it is safer in the majority of cases to at once open the air passages by performing the operation of laryngotomy or tracheotomy according to the situation of the fracture. This proceeding places the patient beyond the risk of the great danger of suffocation in which he stands. For, as Mr. Durham has justly pointed out, "the dyspnœa may recur suddenly at any moment and almost without warning." * Besides this, a free opening into the air passage gives the surgeon an

* Dr. Hunt, in the *American Journal of the Medical Sciences*, April, 1866, p. 378, after giving a tabular statement of all the cases of fracture of the larynx and rupture of the trachea which he could find on record, says: "I think that our list shows that active and prompt treatment by laryngotomy or tracheotomy gives the only hope of success, where the emphysema and bloody expectoration show that the mucous membrane has been lacerated by the broken fragments. . . . If, then, after getting the history of a case, we have bloody expectoration and emphysema accompanying the other symptoms, an operation should be at once performed, for we have obtained no record of such a case getting well without it."

opportunity of endeavouring to return the displaced cartilage to its normal position, by means of some instrument such as a director or female catheter introduced into the wound. By this means he may elevate the depressed cartilage and restore it to its proper place, a proceeding which could scarcely be accomplished in any other way.

If there is any difficulty in maintaining the cartilages in position after their restoration, an instrument constructed on the principle of Tredlenburg's "tampon cannula," may be devised for this purpose.

If there should be any difficulty in deglutition, as in these cases there frequently is, the patient should be fed with fluid food introduced into the stomach by means of a large-sized gum elastic catheter passed down the œsophagus and connected with a stomach pump. This is a preferable plan to introducing the stomach pump tube, the large size of which has a tendency to displace the fractured cartilage. Silence on the part of the patient must be strictly enjoined.

CHAPTER II.

FRACTURE OF THE BONES OF THE CHEST.

Fracture of the Sternum.

The sternum is a light and fragile bone, composed of finely cancellated tissue, covered over with a thin layer of compact structure. We should imagine, therefore, that it would be frequently broken; but, on the contrary, owing, no doubt, to the elasticity of the ribs and their cartilages, which support it like so many springs, fracture, as a separate injury, is of rare occurrence. As a complication of fracture of the spine, or more

rarely fracture of the ribs or clavicle, it is not an uncommon injury.*

Fracture of the sternum most frequently occurs in the body of the bone, generally somewhere about the middle or between this point and the upper border. Occasionally, the lower part of the body or the ensiform cartilage is broken, and in some few instances fracture of the manubrium has been recorded. Dislocation of the first from the second piece of the sternum not unfrequently occurs, and is often classified as a form of fracture of this bone. It is, however, a true displacement of the two articular surfaces of an arthrodial joint, and ought not to be considered as a solution in the continuity of the bone. It will be referred to again in the section on dislocations.

Causes.—The sternum may be fractured by direct violence, by indirect force, or by muscular action. The fractures by direct injury are produced by great violence, as the passage of a waggon wheel over the body, buffer accidents, or the fall of heavy masonry or timber on the chest. Fractures by indirect force may be produced in several ways: as (1) by forcible *flexion* of the dorsal region of the spine; (2) by forcible *extension* of the dorsal region of the spine; (3) by falls or blows on the head and impaction of the chin against the top of the sternum; (4) by falls on the shoulder, when the force is transmitted to the sternum either through the clavicle (Maisonneuve) or through the ribs (Rivington); (5) by falls on the buttocks or feet. Cases of fracture of the sternum by muscular action have been occasionally recorded.

The direction of a fracture of the sternum is almost

* Gurlt states that out of 13,000 cases of fracture only 30 were examples of fracture of the sternum, and in the *British and Foreign Medico-Chirurgical Review* it states that in the London hospitals from 1842 to 1860, out of 21,000 cases of fracture only twenty were cases of fractured sternum.

always transverse, with occasionally a slight obliquity. In some few of the recorded cases the direction has been longitudinal.

In the transverse fracture there is sometimes no displacement. When displacement occurs the lower fragment is almost always displaced forwards, and sometimes it slightly overrides the upper fragment. The preparation from which the accompanying drawing was taken proves, however, that displacement may take place in the opposite direction (Fig. 19). Similar cases have been also recorded by Sabatier, Lawrence,* and Rouse.†

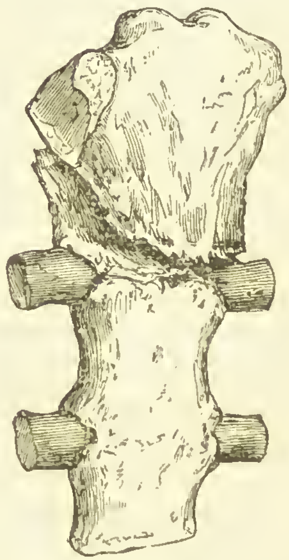


Fig. 19.—Fracture of the Sternum.

There is a fracture of the first piece of the sternum; the fracture running obliquely, from behind, downwards and forwards. The lower fragment is displaced slightly backwards and upwards. Taken from the body of a man who had also fracture of the ribs and laceration of the lung. (From a preparation in the museum of St. George's Hospital, series i., prep. 60.)

Symptoms.—The signs by which this fracture may be recognised are sufficiently clear, and when displacement has taken place are unequivocal. The only other lesions for which it may be mistaken are dislocation or diastasis of the joint between the manubrium and gladiolus and congenital malformations, which are by no means uncommon in the sternum, and produce irregularities on the surface of the bone which may be mistaken for fracture. In many instances the patient will complain of having felt a distinct snap at the moment of the accident,

* *Medical Times and Gazette*, vol. i., p. 233; 1877.
† St. George's Hospital Reports, vol. ix., p. 245. 1855.

and he frequently assumes a distinct and characteristic attitude. The head and trunk are bent forwards and carried in a fixed and rigid manner, and any effort to straighten the body is attended with great pain. The pain is of a fixed character, and is increased by any movement; by taking a deep inspiration or by any violent expiratory effort, such as coughing. Crepitus may generally be detected, if there is no displacement, by placing the palm of the hand over the painful part and directing the patient to take a deep inspiration; or it may be heard by placing a stethoscope over the seat of the injury. If there is any displacement there is a marked deformity, consisting of an abrupt prominence with a depression above it, when the displacement is that which usually occurs. Occasionally, also, the lower fragment may be seen to move on the upper one at each respiratory movement. If there is much displacement so that the fragments overlap each other, crepitus will be absent.

Simple uncomplicated cases of fractured sternum usually do well, but it must always be borne in mind that these cases are commonly complicated with fracture of some other bones, as the spine, ribs, or clavicle, and therefore a careful examination should be made before a too favourable opinion is given. Some instances have been recorded in which the fracture has been attended by extravasations of blood into the anterior mediastinum, and which have been followed by suppuration in the same situation.

Treatment.—In those cases where the fragments are not displaced the treatment is the same as for fractured ribs; the chest must be confined and kept as immovable as possible by means of a carefully applied rib roller, and it will be found that union will take place rapidly. If there is much displacement an attempt should be made to restore the bones to their normal position; and though this may be easily

accomplished, great difficulty will be experienced in maintaining them there, as there is a great tendency for the displacement to recur. Should, however, the surgeon not succeed in keeping the bones in good apposition, no great harm will be done. They will unite in this new position, and no evil consequence appears to result.*

The best means of obtaining reduction of the fragments is to lay the patient on his back, with a pillow under the chest, so that the body is arched backwards, when the bone will probably recede at once into its place. The plans suggested by Petit, of cutting down and elevating the depressed fragment; or of Nélaton, of introducing a hook through a narrow incision and so raising the depressed bone, will scarcely be regarded as justifiable by surgeons of the present day.

It is a good plan in these cases to place the patient in a bed chair. It is generally the position in which he will breathe with greatest ease and will be the most comfortable to him, and at the same time it is the position which will be most likely to maintain the broken ends in position. The diet should be unstimulating and easily digestible. Should abscess occur inside the chest, it must be allowed to find its way to the surface at the margin of the sternum between the ribs, as it eventually will do, unless it sets up pleurisy or pneumonia, which may terminate the existence of the patient.

Fracture of the Ribs.

The ribs are very elastic and much curved. They are connected in front to the sternum by highly elastic cartilages, and behind to the vertebral column by strong ligaments. Moreover, they are strengthened on their concave surface by a strong ridge. They are therefore able to withstand great force and

* See *Medical Times and Gazette*, vol. i., p. 233; 1885.

resist great pressure without breaking, yielding under the injury and recovering themselves like a spring. Nevertheless, from their being so much exposed to violence they are very frequently broken. With the exception of the clavicle and the bones of the fore-arm and leg, they are more frequently broken than any other bones in the body. Gurth, in his statistics of a large number of fractures of all bones, puts fracture of the ribs at nearly sixteen per cent. of the whole number. As might be expected, from their greater exposure to accidents, the injury is much more common in males than in females. It occurs also more frequently in persons of advanced life, being a very rare injury in children, and only produced in them by an extreme amount of violence. This, no doubt, is due to the great elasticity of the thorax in childhood, so that sufficient force has been applied to the chest to cause injury to its contained viscera, without the ribs being broken; whereas in old age the cartilages ossify and the ribs themselves become rigid and lose their elasticity, and often undergo a species of gradual atrophy, so that they are more prone to give way under a much slighter degree of violence than would be necessary to produce fracture in a child or young and vigorous adult. The ribs are also, in advanced life, prone to undergo a sort of osteomalacic change, especially in the general paralysis of the insane, to which allusion has already been made (page 6), which renders them especially liable to fracture under very slight degrees of violence, or even in some cases spontaneously.

With regard to the special ribs which are most liable to fracture, the middle of the series, on account of their being more exposed to injury and less protected by a fleshy covering of muscles, are the ones which are most frequently broken. The fourth, fifth, sixth, seventh, and eighth ribs are therefore the ones

which suffer most frequently; of all, the seventh is the one which is broken more commonly than any other. The first rib generally escapes, and cases in which it has been fractured have rarely been recorded; in fact, some authors say that it is unknown.* Mr. Hulke has, however, recorded a case as occurring in a child who was run over and who died within a few hours of the accident. At the post-mortem examination a fracture of the first rib *only* on the left side was found, together with laceration of the costal pleura and minute rupture of the lung.† The second and third ribs are also so well protected that they generally escape fracture. A case of fracture of the second rib only in a child is recorded as having occurred in University College Hospital. The child had been run over by an omnibus.‡ And the last two ribs on account of their loose and floating condition enjoy an almost complete immunity, and cases of fracture are rarely met with.

Causes.—The ribs may be broken by any of the causes which produce fracture. Great violence, as from severe blows, buffer accidents, or being run over, may produce fracture, either by direct or indirect force. When a rib is broken by direct violence the lesion occurs at the point struck, one or more ribs may be broken, and there is a tendency for the fractured ends to be driven inwards and to lacerate the pleura and, it may be, the viscera contained in the thorax. When a fracture occurs from indirect violence the force of the injury tends to approximate the two ends of the bone, and thus increases its curve, and if the force is sufficient to produce curving of the bone beyond a

* Mr. Arbuthnot Lane exhibited to the Pathological Society two specimens of fractured first rib. He believes that this rare fracture is produced by force applied to the clavicle and transmitted to the first rib (*Lancet*, vol. i., p. 62; 1885).

† "System of Surgery," vol. i., p. 808.

‡ *Lancet*, vol. ii., p. 538; 1860.

certain point, the fibres give way and a fracture occurs at some distance from the point struck. This is generally somewhere about the middle of the bone, though Malgaigne states that in a series of experiments made on the dead body he found that in producing fractures by indirect violence the lesion often took place considerably in front of the centre of the bone. It may also take place behind this point, even as far back as the angle, or even posterior to it, at the neck of the rib, the position of the fracture appearing to depend in a great measure upon the direction in which the force is applied. In fractures from indirect violence two or more ribs are generally broken, and, as might be expected from the manner in which the lesion is produced, there is a tendency for the fractured ends to be driven outwards, and less danger, therefore, of injury to the thoracic contents. Professor Bennett appears to doubt this, for he states that in an examination of seventy cases of fractured ribs in not a single instance did he find any displacement outwards, though in many of the cases the fracture was manifestly produced by indirect force, and that in some of the cases there was a "slight bowing inwards, or flattening of the normal curve, with perhaps a change in the even course of the spiral twist of the rib." Fracture of the ribs may also be produced by muscular action. Malgaigne has collected eight examples of this, but believes that in all the cases the ribs had previously undergone atrophic change. But that this is not invariably the case is proved by several recorded examples.* Fracture of the ribs has also been said to occur from violent muscular efforts during parturition.

When fracture of a rib occurs it is generally

See, among others, cases by Castella, *Glasgow Medical Journal*, April, 1862; Gröninger, *Medical Times and Gazette*, vol. i., p. 450, 1862; and Piffard, *Medical Times and Gazette*, vol. ii., p. 441, 1860.

transverse, or slightly oblique. A rib may be fractured in more than one place, constituting one form of multiple fracture. The more common form of multiple fracture is, however, where several ribs are broken at the same time, a very frequent form of injury, especially when the fracture is produced by indirect violence. Fractured ribs may be compound, either with an external wound through the skin, though this is not a common complication except in gun-shot injuries, or with an internal wound through the pleura, when the broken end of the bone may also lacerate the lung. When this takes place, extravasation of blood may occur either into the pleural cavity (*hæmo-thorax*) or into the lung tissue (*pulmonary apoplexy*), or blood may be coughed up through the air passages (*hæmoptysis*), or effusion of air may take place into the subcutaneous cellular tissue (*emphysema*), or into the pleural cavity (*pneumo-thorax*), or into the lung structure (*pulmonary emphysema*). Lastly, inflammation of the lung, or pleura, or both, may result as the consequence of the injury done to them. In some few cases of fractured rib the pericardium and the heart have been lacerated, or the diaphragm has been perforated and the abdominal viscera, the liver, spleen or intestines injured. The intercostal vessels are occasionally torn by a fractured rib, and the injury is frequently fatal. Despartes records a case where the vessel was ligatured and the patient recovered.

Symptoms.—The symptoms by which fractured ribs are to be recognised are sufficiently well marked, and when all are present there can be no mistake as to the diagnosis. At the same time, however, it must be confessed that in many cases of severe contusion to the chest wall there is considerable difficulty in coming to a definite conclusion; some of the symptoms hereafter to be mentioned being present, but others, especially crepitus, being absent, so that there is a

tendency in some cases to diagnose the injury as one of fractured ribs when perhaps no fracture exists, while on the other hand it must be remembered that crepitus in these cases is often very difficult to elicit, and therefore if the presence of this symptom is disregarded a real fracture of the rib may perchance be overlooked. The history which the patient is able to give is often of extreme value in these cases, for he will often assure us that at the time of the accident he felt something give way with an audible snap, and he will be able to put his finger on the exact spot where he felt the lesion occur. He will complain of a sharp, catching pain in breathing, which is increased by any violent inspiratory or expiratory effort. Upon examining the affected side there will be found to be very little movement during respiration, the injured side of the chest scarcely moving and the respiration being carried on mainly by the diaphragm. Upon careful investigation crepitus may be elicited, and there are three ways in which the surgeon should proceed in order to obtain evidence of this, the most important sign of a fractured rib. In the first place it may be felt by laying the palm of the hand over the painful part and directing the patient to take a deep inspiration. The movement of the chest wall may then cause the one fractured end to grate on the other and thus crepitus may be perceived. Secondly the fingers may be placed one on either side of the supposed seat of fracture, and alternate pressure being made the fractured ends may be made to rub on each other, and thus crepitus may be obtained. Lastly, it may be heard by applying a stethoscope to the injured part, when the movement of the ribs during inspiration produces a slight friction of the broken ends on each other, which can be distinctly heard. Other symptoms of fracture are generally absent. Thus, there is usually little deformity unless several consecutive

ribs are broken, and therefore no irregularity in the outline of the rib can be made out, especially if the fracture be situated behind the centre of the chest where it is more or less covered by muscles. When the fracture takes place in front the irregularity can be sometimes perceived.

Increased mobility of the fractured bone is rarely to be perceived, but on account of the elasticity of the rib, a deceptive sensation of preternatural mobility may be conveyed to the hand of the surgeon, which he must not mistake for motion of the one fragment on the other.

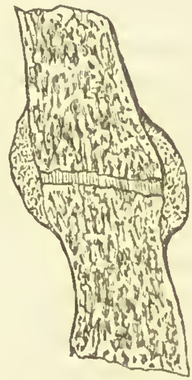


Fig. 20.—Union of Fracture of a Rib.

A portion of a rib, showing union three months after the accident. The fragments are surrounded externally with bony callus and internally are united by fibrous tissue. (From a preparation in the museum of St. George's Hospital, series i., prep. 72.)

In a simple uncomplicated case of fractured ribs the prognosis is favourable. The cases, as a rule, do well. When, however, the case is complicated with injury to the viscera, the danger depends on this lesion and not on the fracture. In gun-shot fractures, also, the gravity of the case depends upon the important organs within the chest being involved, the fracture of the rib constituting only a minor part of the injury. The principal source of danger in cases of uncomplicated fracture is when they occur in the aged, the subjects of old bronchitis or other form of chronic lung disease, and in whom, on account of the injury to the chest wall, there is an inability to free the bronchial tubes of their secretion, and thus a gradual accumulation may take place, causing deficient aëration of the blood, and a gradual death from asphyxia.

Fractures of the ribs unite rapidly by ensheathing callus, since it is impossible to maintain the fragments in a condition of rest. This is well shown in the preparation from which the accompanying woodcut is taken, where three months after the accident it was found that the ends of the bone were ensheathed externally with a considerable amount of bony callus, but internally were united by fibrous tissue only (Fig. 20).

Treatment.—The object of the surgeon in the treatment of fractured ribs is to maintain them as far as possible at rest, and so prevent pain to the patient in breathing. He need not concern himself with removing the deformity, as any displacement which may exist usually remedies itself. The depressed ribs generally expand under the influence of the respiratory movements, and should they not do so, it is better to leave them alone, rather than resort to operative measures, as has been sometimes suggested, by means of elevators or sharp hooks, in order to restore them to their normal position, such proceedings being fraught with danger to the thoracic contents. The most efficient means of maintaining the ribs at rest is by the application of broad strips of adhesive plaister, applied to the affected side of the chest, and extending from a little beyond the sternum in front to a little beyond the spinal column behind. Each strip should be about two inches broad. They should be applied from below upwards, in such a manner that each strip overlaps the half of the one which preceded it, and the whole of the affected side of the chest should be covered. This plan affords a much better support than the old-fashioned one of swathing the whole of the chest in a rib roller, which not only compresses and interferes with respiration on the opposite side, but very soon becomes displaced, and does not give that support and comfort

to the patient which he obtains from carefully and well-applied strapping. Occasionally, also, it will be found that the patient will be unable to bear the constriction of a bandage tightly applied to the chest, but will complain of great pain and dyspnœa upon its application. This is rarely the result of the adhesive strapping, which gives support and comfort to the patient, without interfering with his breathing, so that he cannot bear to be without it. If the surgeon elect to apply the rib roller, it should be applied to the whole thorax, from the lower ribs upwards, and should be commenced when the patient has emptied his chest as far as possible. After it has been applied, a piece of bandage should be connected with the roller in front, and carried over the shoulders and fixed to the roller behind, to act as a pair of braces, and prevent slipping. A third plan which has been proposed is, to apply a roll of adhesive plaister a foot in width, one and a half times round the chest. This possesses the same disadvantage as the rib roller, compressing the sound side of the chest, but is not, like it, so likely to slip. It cannot, however, be applied with the same smoothness and accuracy as the strips of plaister, and does not give the same efficient support.

It is not necessary to confine a patient to bed for a simple uncomplicated fracture, and, indeed, the patient will find that he breathes with greater ease and freedom while in the sitting or erect position, so that it will often conduce to his comfort to prescribe rest in a bed-chair rather than in the recumbent position. The diet must be light and nutritious, and stimulants must be interdicted. Complications must be treated on general principles. If symptoms of inflammation of the lungs or pleura appear, antimony in a saline mixture is a valuable remedy. If constant cough trouble the patient, expectorants and demulcents

must be exhibited. Occasionally, in these cases, alarming chest symptoms set in from engorgement of the lungs, the patient becomes cyanosed, with dusky countenance and hard pulse. Under these circumstances the abstraction of blood from the arm will at once relieve him, and may need to be repeated should the symptoms recur.

Fracture of the Costal Cartilages.

Fracture of the cartilages connecting the ribs to the sternum is a comparatively rare accident. At all events, it is rarely recognised during life; but it seems probable that it may occur more frequently than is generally supposed, and escape observation, for one cannot fail to be struck, in referring to the literature of the subject, by the number of cases in which the lesion has been discovered in bodies used for dissection. It seems fair to infer from this that the accident occasionally occurs during life, and in the ordinary post-mortem examination is overlooked, whereas in subjects in the dissecting-room, where every part is carefully scrutinised, it is discovered. Boyer, who was one of the first to describe these fractures, stated that it was not susceptible of taking place until the cartilage has undergone ossification, but later on saw fit to modify this opinion. No doubt fracture is much more common in the aged after ossification has taken place; but that it may occur in the young and middle-aged before the cartilages have undergone any amount of change, is proved by numerous recorded cases. Malgaigne records a case in which it occurred at the age of seventeen years.

Fracture of the cartilages of the ribs is generally produced by direct violence, and, under these circumstances, the eighth is the one most commonly injured, the seventh or the ninth suffering next in frequency.

According to Boyer, the cartilages from the fifth to the eighth are the ones most liable to fracture. Fractures of the costal cartilages are also produced by indirect force, either as complications of graver injuries, or, as regards the first and perhaps the second, as the results of blows on the point of the shoulder.* Lastly, according to Gurth, fracture of the costal cartilage may occur from muscular action.

The fracture is almost always transverse, or presents only a very slight degree of obliquity, as in one or two recorded cases.

The amount of displacement is often very slight, sometimes so slight that the fracture escapes detection. In other cases it is greater, and one or other fragment may be displaced backwards, or one fragment may overlap the other.

Majendie found that in all his cases where this overlapping took place, the "external fragment passed behind the internal," and this appears to be the more common displacement. Delpech, however, believes that this only occurs when the fracture takes place near the sternal extremity of the cartilage, and that when the injury is situated near the vertebral extremity, the external or costal fragment lies in front of the internal or sternal piece. The displacement which occurs appears to be due mainly to the force of the blow which produces the fracture, but, according to some authors, must be attributed to a certain extent to the action of the triangularis sterni and other muscles.†

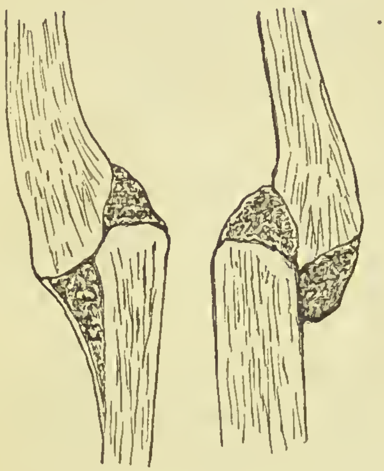
Symptoms.—If there is no displacement of the fragments, the diagnosis of fracture of the costal cartilages is difficult, and there are no symptoms by

* *See* a paper by Mr. Arbuthnot Lane; Path. Soc. Trans., vol. xxxv., p. 253.

† *See* a paper by Professor Bennett; *Dublin Quarterly Journal*, vol. lxiv., p. 333.

which it can be accurately diagnosed, so that the injury is liable to be overlooked.

The only symptoms are persistent pain over the seat of the injury, with swelling, followed shortly by discoloration from extravasated blood. Possibly, also, an obscure sensation of crepitus may be felt by carefully manipulating over the injured cartilage, but this is by no means a constant sign. If displacement has occurred, the diagnosis is rendered more easy by the presence of an irregularity in the line of the cartilage and the increased mobility, which may be felt in the projecting fragment.



Figs. 21 and 22.—Union in Fracture of the Costal Cartilages.

In the first figure the angles formed by the displacement of the fragments are filled up by bony deposit, both internally and externally. In the second figure the angle on the outer surface is filled up by a triangular mass of bony material, while on the pleural surface, the extremity of the outer fragment is capped with a conical mass of bone. (From two preparations in the museum of St. George's Hospital, series i., preps. 67 and 68.

Fractures of the costal cartilages usually unite by bone, sometimes by a mixture of bone and cartilage. In the museum of St. Bartholomew's Hospital are three specimens showing union of costal cartilage; one is by bone; one by a substance like cartilage, with small deposits of bone in it; one by fibro-cartilage alone. When the fractured ends are in apposition, and there is no displacement, union usually takes place by a ring of bone around the broken ends, and adhering closely to them; sometimes by osseous matter between the ends of the fracture, in the form of a thin plate. Paget states that ossification of the

part of the cartilage contiguous to the fracture also takes place. When displacement has occurred, and the fragments overlap each other, it is usually stated that union is effected by osseous matter deposited in the angle formed by the two portions of cartilage on their *pleural surface only;* and Professor Bennett has explained this by reference to a case in which, on the outer surface of the fractured ends, the perichondrium was completely torn through, while on the inner or pleural surface, where the bony deposit had taken place, it was stripped up from off the cartilage to the extent of about three-quarters of an inch, and formed an arch between the two fragments in this displaced condition.* That this is not invariably the case is proved from two preparations in the museum of St. George's Hospital, from which the accompanying woodcuts are taken (Figs. 21 and 22). In Fig. 21 it will be seen that the angle formed by the two fragments, both externally and internally, is filled up by bony deposit, and not that on the pleural surface only. And in Fig. 22 the angle on the outer surface is filled up by a triangular mass of bony material, while on the pleural surface the extremity of the outer fragment, which lies behind the other, is capped by a conical mass of bone, which, however, does not completely fill in the angle, and appears to be little concerned in uniting the two fragments together.

The *treatment* is the same as that for fractured ribs. If the fragments can be manipulated into position, this should be done; but it is generally very difficult or impossible to overcome the displacement, and no great harm appears to result from leaving them in this abnormal position. Malgaigne recommends the employment of a truss, the pad of which is placed over the prominent end, and by its continuous pressure reduction is said to be effected, and the

* *Dublin Quarterly Journal*, vol. lxiv., p. 335.

fractured extremities maintained in position. The prognosis is good, consolidation usually taking place in from twenty-five to forty days.

CHAPTER III.

FRACTURES OF THE BONES OF THE UPPER EXTREMITY.

FRACTURE OF THE CLAVICLE.

THE clavicle is more frequently broken than any other bone in the body. This is due to several causes, but mainly to the fact that it is exposed to the full force of any blow on the shoulder, or of any shock communicated to it from the upper limb. Its extremities being securely fixed by ligaments, dislocation is rare, and therefore the full force is thrown on the bone, which gives way under the strain. No doubt fracture would be much more common than it is, were the bone not disposed in the form of two curves, having opposite directions, so that the forces applied to it are diffused over a greater space, and are broken up by the elasticity which the curved form imparts. In consequence of this arrangement of the bone in curves, when it breaks from the effect of indirect violence we generally find that it gives way a little external to the middle of the bone, where the inner and larger curve joins the smaller external one. The bone is here smaller than in any other part, and is more fixed in position.

Fracture of the clavicle is most common in infancy and early childhood, although it may occur at all ages, "at least one-half of the recorded cases occurring before the completion of the fifth year" (Hulke).

Fracture of the clavicle generally occurs, as above stated, at a point a little external to the middle of the bone, and this is a fairly constant position in fractures occurring from indirect violence; but any part of the shaft may be broken from direct force. Fractures may also occur at either the acromial or sternal extremity; the former being the more frequently broken, on account of more immediately receiving the force of the injury.

It will be convenient, therefore, to consider fractures of the clavicle under three heads; (1) Fractures of the shaft; (2) fractures of the acromial extremity; (3) fractures of the sternal extremity.

Fractures of the shaft.—Fractures of the shaft of the clavicle are generally produced by indirect violence, as falls on the point of the shoulder, or on the hand when the arm is outstretched from the side. In these latter cases the force is transmitted from the hand through the bones of the fore-arm and arm to the shoulder joint, and from it is transmitted to the clavicle, which, being fixed at its sternal extremity by strong ligaments, is compressed between two opposing forces, and gives way at its weakest part. These fractures are therefore usually oblique in direction. Accordingly, we find that fracture of the clavicle is very common in young children, who, in running, stumble, and putting out the arm to save themselves, fall upon the hand, and thus break the bone. It is also common in infants from falling out of bed or from a chair on to the point of the shoulder. In these cases the fracture is not unfrequently incomplete. In fact, the clavicle is more frequently the seat of greenstick fracture than any other bone in the body. Mr. John H. Packard believes that the clavicle is often broken, when the force is applied downwards and backwards to the outer end, as in the recoil of a gun loosely held, by being levered against the first

rib, which acts as a fulcrum, and snaps the bone across at its weakest part.*

The shaft of the clavicle may also be broken by direct force, as from blows or a heavy weight falling upon it. The fracture may then take place at any part of the bone, but more usually occurs in the outer than the inner half, since it is more exposed to injury. When produced in this way it is usually transverse, but may be comminuted. The clavicle may in rare instances be broken by muscular action alone, and several cases of this accident have been recorded.† Treves states that Polaillon, "from a careful analysis of the reported cases, concludes that the muscles that break the bone are the deltoid and the clavicular part of the great pectoral." ‡

The usual oblique fracture is always attended with considerable displacement, due mainly to an alteration in position of the outer fragment. The inner fragment undergoes little displacement, any tendency which the sterno-mastoid muscle would have to draw it upwards being prevented by the rhomboid ligament, and counteracted by the pectoralis major muscle. There is, however, in some cases, a slight tendency in the outer end of this fragment to be tilted slightly upward, especially in cases where the treatment has been neglected. Mr. Hulke records a case in which the sternal fragment projected upwards at an angle of 45°, and formed a visible prominence in the neck. In these cases it is probable that the displacement is not directly upwards, but

* *Brit. Med. Journal*, vol. i., p. 12 ; 1885.

† A case is recorded by M. Mclay, *Gaz. Hebd.*, p. 684 ; 1863. It is also stated that the celebrated tenor, Rubini, while singing in the opera of "Il Talimano," at the great La Scala Theatre, at Milan, broke his clavicle in overcoming the difficult task of rendering a B-flat fifteen times in succession ("History of the Opera," vol. i., p. 270).

‡ "Surgical Applied Anatomy," p. 171.

forwards and upwards, the direction of the fibres of the rhomboid ligament being backwards; a movement forwards would relax the ligament somewhat, and permit of a slight upward displacement. The outer fragment is mainly drawn downwards and inwards, but in addition to this, it is somewhat rotated, so that its outer extremity is thrown forwards and its inner backwards. The downward displacement is principally due to the weight of the arm and the action of the pectoralis minor muscle, perhaps assisted by the latissimus dorsi, the lower fibres of the pectoralis major and the deltoid acting from below. Dr. Cathcart believes that the downward displacement is due to the fact that after fracture the trapezius is not strong enough to maintain the weight of the shoulder. Following Duchenne and Cleland, he believes that the shoulder is really suspended in position by the action of the trapezius muscle, and that the clavicle acts as a lever, with a fulcrum at the sterno-clavicular joint. When fracture takes place the trapezius is unable to support the weight of the arm, having lost the additional power

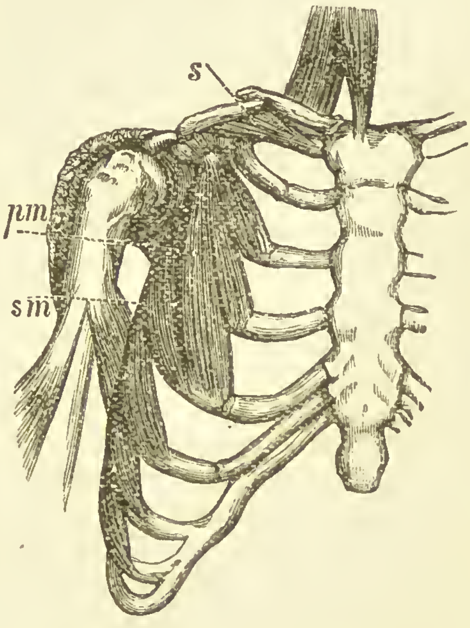


Fig. 23.—Fracture of the Clavicle.

The figure shows the displacement which occurs in the ordinary fracture of the clavicle. *s*, subclavius; *pm*, pectoralis minor; *sm*, serratus magnus. (After Hind.)

which it formerly gained by the clavicle acting as a lever.*

The inward displacement is produced mainly by the action of the pectoralis minor and subclavius, assisted by the pectoralis major (Fig. 23). The rotation of the outer fragment is almost entirely due to the serratus magnus, which carries the acromion process forwards by causing the scapula to rotate on the side of the chest. Thus the outer end of the fragment attached to the acromion is drawn forwards, while the inner end, by a partial rotation of the piece of bone, is directed backwards.

Professor Gordon believes that the cause of this displacement is due partly to the shape of the thorax, but principally to muscular action. When the clavicle is broken, the outer or acromial portion of the scapula, which is not naturally in contact with the cone-shaped thorax, but is held outwards by the clavicle, falls forwards, inwards, and downwards. "The form of the thorax conduces to this movement, but the chief agents are the serratus magnus, lesser pectoral, and subclavius muscles." These muscles would draw the scapula forwards round the chest, and also inwards, so that the acromial angle of the scapula would be brought in contact with the wall of the thorax, and thus the acromial process and outer fragment of the clavicle would be depressed, though the base of the scapula would maintain its relative position on the ribs.†

In consequence of this threefold displacement the inner end of the outer fragment is placed beneath and a little behind the sternal fragment, which overrides it, and there is a diminution in the length of the bone, sometimes to the extent of an inch.

* *Brit. Med. Journal,* vol. ii., p. 416; 1884.

† *Dublin Quarterly Journal,* vol. xxviii., p. 480; 1859. *See* also a paper by Mr. Packard, who takes the same view; *Brit. Med. Journal,* vol. i., p. 12; 1885.

Complications.—In spite of the great displacement which takes place and the manner in which these fractures are for the most part produced, namely, from indirect violence, they are very rarely compound, though the bone is subcutaneous throughout its whole length. This is due to the very loose way in which the skin is connected to the bone, so that it plays freely over it, and to the fact that the inner end of the outer fragment is usually displaced backwards and not forwards under the skin.

Both clavicles are occasionally, though very rarely, fractured, of course as the result of direct violence. There is in St. George's Hospital museum a preparation of both clavicles simultaneously fractured by the falling of a large branch of a tree, under which the patient was standing.

In the ordinary oblique fracture of the clavicle there is hardly any complication of importance. In the direct fracture, however, the same force which produced the fracture may drive the broken end of the bone or a comminuted fragment into some of the important structures which lie beneath.* Paralysis and wasting of the muscles with loss of sensation is an occasional result of these fractures. This in some cases is no doubt due to laceration or compression of the nerves of the brachial plexus; but, as Dr. Hamilton has pointed out, this will not satisfactorily account for all of the examples of paralysis following simple fracture. He believes that it is sometimes due to the injudicious use of the axillary pad in the treatment of the case, which produces a form of paralysis analogous to "crutch palsy."† In some cases of fracture of the clavicle from very great violence the ribs may be also broken and the pleura injured,

* *See* a clinical lecture by Mr. Erichsen; *Brit. Med. Journal*, June 7, 1873.

† "Fractures and Dislocations," p. 188.

as in a case under Mr. Erichsen's care, where both clavicles and twelve ribs were broken in a railway accident.*

Symptoms.—The signs by which we recognise fracture of the clavicle are so unequivocal that the injury is scarcely ever likely to be mistaken for anything else. It is, however, occasionally overlooked, especially in infants who have received some injury, as though a fall from a bed, which has not been regarded as of sufficient importance to require medical aid. In the adult the characteristic position which the patient assumes is in itself almost sufficient to diagnose the injury. Upon stripping and examining a patient with fracture of the clavicle, he will be found to stand with his injured arm close to the side, with the sound hand supporting the elbow or wrist so as to take off the weight from the injured bone. The shoulder will be noticed to be flattened, and on a lower level than that of the opposite side of the body. It will also appear to be approximated to the middle line of the body, so that there will appear to be less distance between the point of the shoulder and the centre of the sternum than on the unaffected side. The head is also slightly bent towards the injured shoulder, so as to relax the muscles passing from the head to the shoulder girdle. The patient is unable to raise his arm from his side. There is a fixed pain in the part, which is sometimes very great, and is much increased by any movements of the arm.

Upon running the fingers along the subcutaneous surface of the bone a marked irregularity will be at once perceived in the ordinary oblique fracture, the inner fragment being felt prominently under the skin with a sharp abrupt margin and a depression beyond it. In the transverse fracture from direct violence

* *Lancet*, Sept., 1861.

this irregularity is commonly not so marked, and may not exist at all.

Crepitus can generally be easily felt, but where the displacement is great, the ends of the bone overlapping each other, it may not be perceived until reduction is effected. The increased mobility in the continuity of the bone will at the same time be noted.

Fractures of the clavicle unite readily, having a tendency to throw out a large amount of ensheathing callus, which quickly binds the broken ends together, so that they are generally firmly consolidated at the end of three weeks. Instances of fibrous union or false joint are very rare, and but few cases are recorded. When this does occur it does not appear to interfere much with the utility of the member. Fractures of the clavicle are very liable to unite with permanent shortening; perhaps there is no bone, with the exception of the femur, in which this so frequently occurs as the clavicle.

This shortening is due to the fact, that though it is generally very easy to reduce the fracture, it is extremely difficult to maintain the fractured ends in position. The tendency to a return of the displacement is very great, and unless the case is watched with the most scrupulous care, and the apparatus, whatever it may be, which fixes the broken fragments, constantly readjusted, deformity is sure to occur, producing sometimes an unsightly projection, which is especially noticeable in thin people, particularly at first, when it is increased by the presence of ensheathing callus. After the lapse of time the callus becomes absorbed, the prominent bone becomes rounded off, and it is astonishing how little of the deformity remains.

Treatment.—In consequence of the difficulty that there is in maintaining the fractured ends of a clavicle in apposition, the number of different appliances which have been devised for treating these cases

is very great. There can be no question that the plan of treating fractures of the clavicle which yields the most satisfactory results, is to lay the patient flat on his back on a firm, hard bed, with merely a small pillow under the head, and to confine the arm to the side by a sand-bag. The weight of the shoulder then drags the bone into position, and if the patient will only consent to remain perfectly quiet in this position without moving for three weeks, union without deformity may be confidently anticipated. It is seldom, however, that a patient will consent to this irksome restraint.

The displacement of the inner extremity of the outer fragment being downwards, inwards, and backwards, in order to overcome the deformity it is necessary to draw the point of the shoulder upwards, outwards, and backwards. And to do this, two principal methods are adopted. The one consists in applying a figure of 8 bandage round the points of the shoulders and crossing it behind the back, wool being carefully adapted to prevent rubbing in the axillæ. This draws the outer fragment backwards. Care must be taken, however, in applying it, that the loop of the figure of 8 shall pass over the *point* of the shoulders, otherwise it will press on the inner end of the distal fragment and increase the deformity which it is intended to remedy. A wedge-shaped pad * is now to be placed in the axilla with the base upwards and the arm bound to the side by a rib roller. The pad then acts as a fulcrum and forces the shoulder outwards, thus overcoming the inward displacement. Finally, a few turns of the rib roller are to be carried under the point of the elbow and over the opposite shoulder in order to act as a sling and raise the

* Mr. Eddowes recommends an indiarubber air pad which can be inflated after it has been adjusted, to any extent which may be deemed necessary (*Lancet*, vol. ii., 679; 1867).

humerus and so push the shoulder upwards and overcome the downward displacement. This complicated arrangement is exceedingly irksome to the patient, the constant drag on the shoulders uncomfortable, and the pad in the axilla, by its pressure on the nerves of the brachial plexus, often causes intolerable pain, and sometimes even worse. An old-fashioned plan, but one which appears to yield very good results, is to substitute a T-shaped splint for the figure of 8 bandage. Two strong laths, one the same length as the patient's shoulders are apart, and the other somewhat shorter, are screwed together in the form of a T, the longer lath forming the horizontal bar. The shoulders are well brought back and fastened to the ends of the horizontal bar by means of a bandage passing under the axillæ, a pad being placed in the arm-pit and the arm kept to the side by a bandage passing round the body and twisted at each turn round the perpendicular splint.

The second plan aims at doing away with the figure of 8 bandage, and in order to draw the shoulder backwards a bandage is applied twice or thrice around the upper part of the arm, so as to obtain a firm hold, and is then carried *behind* the body so as to draw the shoulder back. A wedge-shaped pad having been previously inserted in the axilla and fixed by a bandage attached to it and tied over the opposite shoulder, the bandage is now carried round the body and arm for a few times so as to bind the humerus to the side. The fore-arm is laid across the chest and is included in the bandage. In both instances the folds of bandage should be carefully stitched together, both in front and behind, so as to prevent their slipping.

A third plan of treating fractured clavicle is by means of a four-tailed bandage. It is one which I have often employed, especially with children, and

with very satisfactory results. It is simple, easily applied, and far less irksome to the patient than either of the foregoing methods; while, at the same time, as far as I have been able to judge, the results are as good and the amount of deformity no greater than in those cases where the other plans have been adopted. Take a piece of strong calico fourteen inches wide * and sufficiently long to go one and a half times round the body of the patient. Cut a hole in the centre, about four inches from the margin, for the point of the elbow. Split up the ends of the bandage in the same line as the hole, that is to say, four inches from the border to within about six inches of the hole. You will thus have a four-tailed bandage, with tails of unequal breadth, one four inches broad, the other ten. Place a wedge-shaped pad in the axilla and lay the patient flat on his back on a bed or table to allow the broken bone to fall into position. Lay the arm to the side and flex the fore-arm on the chest. Now apply the bandage in such a manner that the point of the elbow shall stick into the hole and the broad tail of the bandage enclosing the humerus be brought across the chest and fastened on the opposite side of

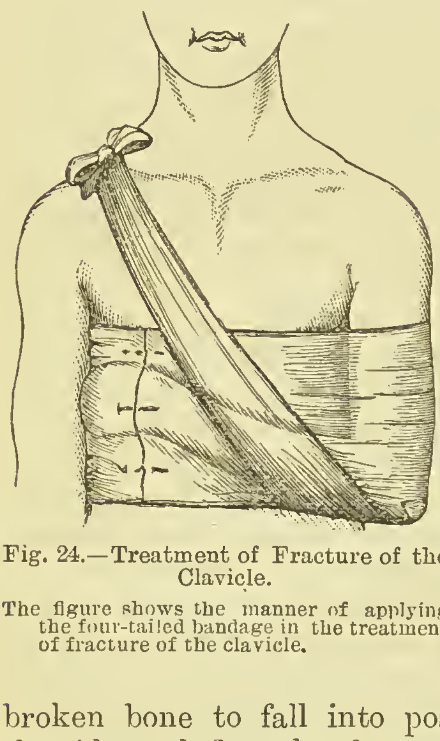


Fig. 24.—Treatment of Fracture of the Clavicle.

The figure shows the manner of applying the four-tailed bandage in the treatment of fracture of the clavicle.

* Of course, for a child it would not require to be so wide.

the body, thus binding the arm to the side. The narrow tail, which will be below the elbow, is now to be crossed over the broad tail and tied over the top of the opposite shoulder (Fig. 24).

Ellis's apparatus is a special contrivance for treating fractured clavicle. It consists of a crutch, which is fixed in the axilla by a broad webbing passing over the opposite shoulder, and to which is attached a pocket into which the extremity of the crutch is inserted. The arm is then bound to the body by a second webbing, which is made to enclose the humerus, passes through two slots in the sides of the crutch, one in front and the other behind, and is buckled on the opposite side of the chest. The hand is supported in an ordinary sling (Fig. 25).

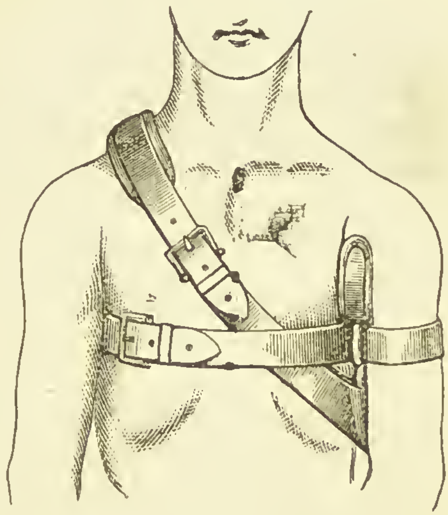


Fig. 25.—Treatment of Fracture of the Clavicle.

The figure shows the manner of applying Ellis's apparatus in the treatment of fracture of the clavicle.

Dr. Gordon, who does not accept the ordinary views as regards the cause of the displacement, has introduced a special apparatus for the treatment of fractured clavicle. (*See* page 150.) He deprecates raising the humerus, and insists that the only essential point of the treatment is to force the scapula outwards and backwards. This he does by applying a shield to the thorax and a metal collar to the arm, and connecting the two by a rod, which can be lengthened or shortened by means of a screw. By lengthening this

rod, the shoulder, and with it the scapula, is driven outwards and backwards.* The apparatus, however, is too costly to be likely to come into common use in hospital practice. Dr. Sayre, of New York, treats fractured clavicle with two strips of adhesive plaister, without any axillary pad. The strips are cut three or four inches wide. The shoulder and arm are drawn backwards and retained there by one strip of plaister carried round the middle of the arm. The elbow is then pressed forwards and inwards, the fore-arm being flexed across the chest; this causes the strip of plaister round the middle of the arm to act as a fulcrum and forces the shoulder upwards, outwards, and backwards. A second strip of plaister is now carried from the sound shoulder across the back and over the elbow, fixing it in the position in which it has been placed, to the sound shoulder again, that is, to the place of starting. Here the two ends are secured by a few stitches.†

Fracture of the acromial extremity of the clavicle.—The acromial end of the clavicle is broken from direct violence more frequently than the sternal end, on account of its being more exposed to injury; for instance, from blows aimed at the head, and striking the top of the shoulder. It may be fractured in two situations: (1) between the conoid and trapezoid ligaments, or (2) external to these ligaments; that is, between them and the acromial end of the bone.

When the fracture takes place between the conoid and trapezoid ligaments, there is, according to Dr. R. W. Smith, but little displacement in consequence of the two fractured ends being held in position, the inner by the conoid, the outer by the trapezoid ligament, and

* Gordon on "Fractures of the Lower End of the Radius and of the Clavicle," p. 60.

† *New York Medical Record*, August 15, 1871.

the only alteration in position is that the natural convexity of the clavicle is slightly increased.* Dr. Gordon, however, does not believe that these ligaments have any effect in preventing displacement, and that the deformity is the same as when the fracture occurs external to the ligaments.† In consequence of the slight amount of displacement the diagnosis of this fracture is by no means easy. There is a fixed pain in the part, greatly increased on pressure and upon making any attempt to move the arm. The movements of the arm are not, however, much interfered with, though productive of pain. Crepitus is generally to be felt by manipulating the fragments and pressing alternately on one and the other.

When the fracture occurs external to the coraco-clavicular ligaments, the displacement is very considerable, much greater than the deformity presented by the patient would lead one to suppose. The displacement generally consists in a partial rotation of the acromial fragment forwards and inwards round an axis through the seat of the fracture. This rotation is sometimes so great that the fractured surface of the outer fragment comes in contact with the anterior surface of the acromial end of the sternal piece of the bone, and the two portions of bone form a right angle with each other. This displacement is due to a rotation of the scapula on the wall of the chest, mainly through the action of the serratus magnus, assisted to a certain extent by the pectoral muscles. Dr. Smith states that the inner end of the outer fragment is raised upwards and outwards by the action of the trapezius, while its articulating surface is directed proportionably downwards and inwards.‡ But in a case exhibited by Mr. Canton at the Pathological

* "Fractures and Dislocations," p. 209. 1847.
† *Dublin Quarterly Journal*, vol. xxviii., p. 478; 1859.
‡ *Op. cit.*, p. 216.

Society, the external fragment had become displaced *below* the inner one.*

There is generally little difficulty in diagnosing this form of fracture. There is marked irregularity to be felt in the outline of the clavicle by running the finger along the subcutaneous surface of the bone. Crepitus is usually elicited with ease by moving the shoulder upwards and downwards, and any movement is attended by severe pain.

The treatment of the fracture between the two ligaments is simple; nothing requires to be done but to fix the arm to the side with a rib roller, and keep the limb quiet until union takes place.

But in the fracture external to the ligaments the greatest difficulty will be experienced in reducing the fracture and in maintaining the broken ends in position. And it is wise to caution the patient that he must be prepared for a certain amount of deformity, though he can, at the same time, be consoled by being assured that it will interfere very little, if at all, with the movements of the limb. As the displacement is due to a rotation of the scapula, the best plan of treatment appears to be for the surgeon to seize the point of either shoulder in his hands, and, standing behind his patient, drag the shoulder, and with it the scapula, backwards until reduction is accomplished. The scapula is then to be fixed in this position by a large pad placed in the infraspinatus fossa, and strapped tightly in position by a broad strip of plaister encircling the chest. A pad is to be placed in the axilla, and the arm bound to the side by a rib roller.

Fractures of the sternal extremity of the clavicle.—Fracture of the sternal extremity of the clavicle is much more uncommon than the preceding. It generally occurs during early life, and may be

* Path. Soc. Trans., vol. xii., p. 161.

caused by direct or indirect violence, though the former is the more frequent cause. The displacement, which results is due to alteration in position of the outer fragment only, the inner one remaining in its natural place. The inner extremity of the outer fragment is drawn forwards, and in some cases also downwards and inwards (Fig. 26). When the displacement is simply forwards, Dr. R. W. Smith

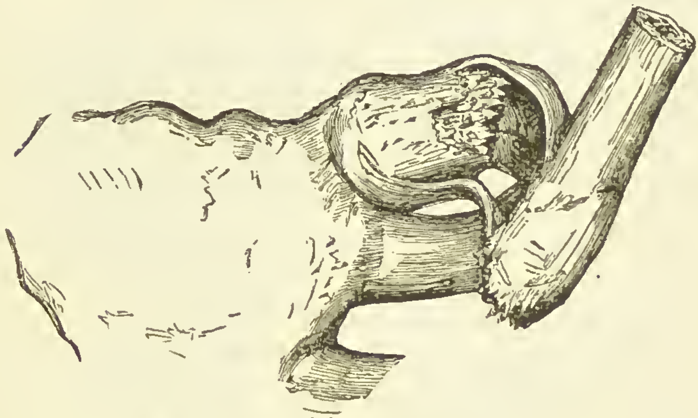


Fig. 26.—Fracture of the Sternal end of the Clavicle.

The fracture has taken place about an inch external to the sternal end of the bone. The outer fragment is displaced downwards and forwards and slightly inwards, on to the front of the cartilage of the first rib. (From a preparation in the museum of St. George's Hospital, series i., prep. 77.)

believes that the fracture has taken place close to the sterno-clavicular joint, between the costo-clavicular and sterno-clavicular ligaments; but that when the outer fragment is displaced downwards and inwards, as well as forwards, it is a certain indication that the fracture has taken place external to the rhomboid ligament.*

Both forms of fracture, but especially the former, where the lesion has occurred close to the joint, simulate dislocation. There is an abrupt and striking projection, on a level with the sterno-clavicular joint. The clavicular attachment of the sterno-mastoid muscle

* *Dublin Quarterly Journal*, vol. iv., p. 14.

is carried forwards with the bone and stands out in bold relief. The shortening of the bone, when compared with that on the opposite side, and the presence of crepitus, is sufficient to determine the true nature of the accident. The treatment of the injury is best carried out by applying the figure of 8 bandage over the shoulders and crossing it behind the back, as recommended sometimes for fractures of the shaft of the bone.

Fracture of the Scapula.

The scapula is less liable to fracture than any of the large bones of the upper extremity. This is due to several causes; to its mobility, to the support which it receives from the thorax and the elasticity of the ribs, to the softness of the cushion of muscles on which it is placed, to the fragility of the clavicle, and the weakness of the shoulder joint.

Fractures may occur either in the body of the bone or through the neck, or the acromion or coracoid processes may be broken; fracture of the acromion process, from its exposed position, being the most frequent injury.

Fractures of the body of the bone are almost invariably caused by direct violence; as when the body is crushed from a buffer accident, or from a fall of masonry, or it may be caused by a kick from a horse, or by the patient being run over, or from gunshot injury.* The infraspinatus fossa is the part most frequently injured, and the bone may be simply fissured, or a star-shaped fracture may be produced, or it may be extensively comminuted, portions of bone being separated and depressed into the tissues beneath. In other cases, fracture of the supraspinatus fossa may take place, or we may have a fissure running from the

* One instance of fracture of the body of the bone by muscular action is quoted in the *Journal de Chirurgie*, May, 1845.

one fossa to the other, and extending through the spine (Fig. 27).

Symptoms.—The signs by which fracture of the body of the scapula is characterised are sometimes obscure, at others sufficiently well marked. There is great pain, especially upon any attempt being made to

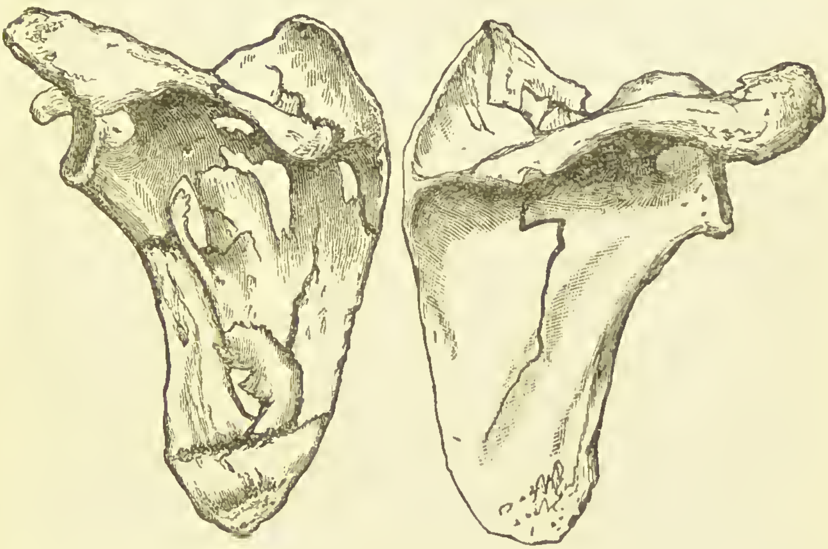


Fig. 27.—Two cases of Fracture of the Scapula.

In the one case the bone is extensively comminuted. There is a fracture running from the supra- to the infraspinatus fossa, through the spine, a portion of which is loosened and slightly displaced. The infraspinatus fossa is traversed by various fractures. In the other case a nearly vertical fracture extends from the supraspinatus fossa through the body of the bone to within two inches of its inferior angle. The fracture in the supraspinatus fossa is comminuted. (From two preparations in the museum of St. George's Hospital, series i., preps. 83 and 84.)

move the bone upon the wall of the chest. There is also great bruising and swelling, which comes on rapidly after the occurrence of the injury. Sometimes mobility in the continuity of the bone may be felt by grasping the acromion process, so as to fix the bone, and then seizing the inferior angle and moving it to and fro; and in this way also crepitus may occasionally be obtained. Sometimes crepitus may be felt by placing the palm of the hand flat over the bone

and moving the humerus. If the line of fracture has crossed the spine and any displacement taken place, the inequality perceived by running the finger along the subcutaneous crest enables us at once to recognise the injury.

Treatment.—Very little can be done in the way of reducing the fragments, and the surgeon will have to content himself with manipulating the pieces, as far as possible, into position, and then keeping the bone rigidly at rest. The fracture unites readily, and although there may be some deformity, it does not seem to interfere, to any great extent, with the ordinary movements of the limb. All that is generally necessary is to support the arm in a sling, and then apply a rib roller enclosing the upper arm, and binding it to the chest. Some surgeons have recommended that guttapercha shields should be modelled to the part, and maintained in position by broad strips of strapping; others the application of a large pad over the scapula, in order to restrain its movements.

Fracture of the neck of the scapula.—Under this head have been included, by different authors, three distinct varieties of fracture.

1. Fracture of the true neck of the scapula, *i.e.* fracture of the narrow, constricted portion immediately behind the glenoid cavity.

2. An oblique fracture running from the lower angle of the glenoid fossa upwards and backwards to the suprascapular notch, through what is called the "surgical neck of the bone."

3. Fracture of the glenoid cavity.

With regard to the first form of fracture, through the **true neck of the scapula**, it is exceedingly doubtful whether such an accident ever occurs; no case, as far as I am aware, ever having been published in which the nature of the injury was verified by dissection. The nearest approach to this form of injury

is a case recorded by Spence and Steel, in which the "fracture was found to pass obliquely from below, upwards and forwards, commencing about half an inch behind the origin of the long head of the triceps, and separating the neck and four-fifths of the lower part of the glenoid cavity."* This case, however, cannot be regarded as a true fracture through the neck, but ought rather to be placed in the third group of cases, as one of fracture of a portion of the glenoid cavity. Mr. Skey also records a case, in which he believed that the glenoid cavity was separated from the rest of the scapula, " either in a large proportion or absolutely."† And Dr. Lotzbeck mentions another case, in which he was of opinion that a fracture of the anatomical neck of the scapula had taken place.‡ But in neither of these last two cases was the injury verified by the post-mortem examination of the patient, as in neither did a fatal issue result.§

Fracture of the **surgical neck** undoubtedly does occur, and has been, according to Hamilton, verified by dissection in a case by Duverney.‖ There is also a specimen of fracture of the scapula in the Hunterian Museum of the Royal College of Surgeons, in which the line of fracture runs from the suprascapular notch to the axillary border of the bone, about three-quarters of an inch below the glenoid cavity, so that the articular surface, neck, and coracoid process have been separated from the rest of the bone. The fracture has united, the specimen having been taken from

* *Edinburgh Medical Journal*, p. 1083; 1863.
† *Lancet*, vol. i., p, 369; 1860.
‡ *Deutsche Klinik*, p. 420; 1867.
§ Mr. West is reported to have exhibited a "fracture of the anatomical neck of the scapula" in a case of machinery accident, which had smashed the humerus and also the radius and ulna, at a meeting of the Birmingham and Midland Branch of the British Medical Association, but no account is given of the direction of the fracture.—*British Medical Journal*, vol. ii., p. 681; 1871.
‖ "Fractures and Dislocations," p. 207.

a dissecting-room subject. There has also been a fracture of the acromion process.

Many cases have been recorded where the injury has been diagnosed during life, but in which recovery has taken place.

The fractured portion of bone, in fracture of the surgical neck of the scapula, is displaced downwards, carrying with it the humerus, and thus simulates dislocation into the axilla. There is flattening of the shoulder, apparent prominence of the acromion process, and the presence of a foreign body in the axilla. Moreover, the arm is lengthened and thrown away from the side. The diagnosis may be made by the displacement which takes place in the position of the coracoid process. This process is connected with the detached fragment, and is, therefore, displaced with it, and is to be felt under the skin below and a little internal to its normal situation. In a recent unimpacted case crepitus can generally be elicited by seizing and moving this process backwards and forwards, or by fixing the coracoid process with one hand and placing the other on the back of the scapula, while the head of the humerus is pushed outward and rotated.* There is increased mobility, especially if an examination be made under an anæsthetic; and, according to Dr. Lotzbeck, symptoms of pressure on the brachial plexus, so common in dislocation, are never present in this fracture. The displaced fragment can generally be reduced with ease, but the deformity recurs as soon as the force employed for its reduction is removed.

The **treatment** of this injury consists in placing

* Dr. Lotzbeck of Munich, in the *Deutsche Klinik*, p. 420, 1867, gives a careful *résumé* of all the cases of this injury which he has been able to collect. He states that crepitus has been described in all the recorded cases but one. An abstract of this paper is given in the New Sydenham Society's "Biennial Retrospect" for 1867-68, p. 240.

the patient under chloroform or ether, and reducing the fracture. While the parts are held in position by an assistant, a wedge-shaped pad is to be placed in the axilla, and a large shield of guttapercha moulded to the shoulder, covering the pectoral and scapular regions, and extending down the arm as far as the elbow. This is to be firmly bandaged in position, care being taken to carry the bandage under the point of the elbow and over the opposite shoulder, so as to prevent the weight of the arm dragging the fragment downwards. The fracture generally unites rapidly in about five to seven weeks.

Fracture of the **glenoid cavity** is not an uncommon accident, and is occasionally complicated with dislocation.* According to Mr. Skey, it is the result of falls or blows on the shoulder, with the arm parallel to the body.† The injury is to be diagnosed principally by negative signs. By the absence of any symptoms of fracture of the clavicle or of the acromion, spine, or coracoid process of the scapula, or of the head of the humerus, and by the presence of well-marked crepitus, especially marked by raising the arm at right angles to the body and pressing the head of the humerus against the glenoid cavity. If the bone is now rotated crepitus will be easily detected; whereas, if the arm is allowed to remain by the side, and no pressure of the head of the bone against the socket is made, the arm will rotate freely, and perhaps without crepitation. The only treatment necessary in these cases is to keep the arm quiet by the side by means of a rib roller applied around the chest and arm.

Fracture of the acromion.—The acromion process of the scapula is more frequently broken than any other part of the bone. This is due to its

* A good illustration is given in Hamilton's "Fractures and Dislocations," Fig. 55, p. 207.

† Clinical lecture; *Lancet,* vol. i., p. 368; 1860.

prominent and exposed position, so that it is more liable to receive the force of blows or falls than other parts of the bone. Hamilton, however, believes that it is not so commonly broken as is supposed, and that many recorded cases of fracture with ligamentous union are really instances of delayed union of the epiphysis to the remainder of the bone. He mentions a specimen taken from an individual, at least forty years of age, in which the acromion was fully formed, but had no bony union with the scapula itself.*

The fracture is always produced by direct violence, and may be transverse (Malgaigne) or oblique (Nélaton), or the extreme tip may be broken off. The symptoms by which it is recognised are well marked; there is pain, and inability to raise the arm from the side; there is dropping of the point of the shoulder, and a peculiar flattened and sunken appearance. On running the finger along the subcutaneous surface an abrupt drop will be felt, and will mark the seat of fracture. Upon moving the shoulder, increased mobility and crepitus will be detected. It will be noted also that the deformity disappears upon raising the elbow, and quickly returns when the arm is again left unsupported.

It is commonly said that the fracture unites by fibrous tissue, and that true bony union is rare; this was believed by Sir Astley Cooper to be due to the difficulty that there is in keeping the parts quiet. The union, whether bony or ligamentous, often takes place with a certain amount of deformity, but this does not appear to interfere with the movements of the arm. Many surgeons believe that cases of chronic rheumatic arthritis have been mistaken for old fractures; and Dr. R. Adams has pointed out that in cases of chronic rheumatic arthritis of the shoulder joint a

* "Fractures and Dislocations," p. 208.

disunion of the epiphysis from the rest of the bone occasionally takes place.*

The **treatment** consists in supporting the elbow, and by this means pressing the head of the humerus against the acromion, and thus, as Sir Astley Cooper says, making it act as "the splint which is employed to keep the acromion in its natural position." This is best done by placing a large soft pad between the elbow and the wall of the chest, and then bandaging the arm to the chest, carrying the bandage under the elbow and over the opposite shoulder, so as to raise it. It is necessary to place a pad in the position indicated, for if the elbow is bandaged too closely to the side, the head of the humerus is thrown outwards and the fragments separated.

Fracture of the coracoid process.—The coracoid process is very rarely broken off as an uncomplicated injury. In most cases where it has been broken, it has been the result of very severe violence, and has been accompanied by fracture of some other part of the scapula, or else it has been broken by the dislocated head of the humerus striking against it.† There can be no doubt, however, that this accident does occasionally occur. Mr. Hulke states that two instances have fallen under his notice, the fracture having been caused, in both instances, by a fall forward from a slight height.‡ It is usually produced by a direct blow, as in a case given by Hamilton, in which a gentleman was struck by a board, which fell edgewise upon his shoulder. In the *Lancet*, however, there is recorded a case by Dr. Edward Hulme, surgeon to the Dunedin Hospital, in which the coracoid process was said to have been fractured by muscular action.§

* "Chronic Rheumatic Arthritis," p. 102.
† Cases of this are recorded by South, Holmes, and Hussey.
‡ "System of Surgery," vol. i., p. 953.
§ *Lancet*, vol. ii., p. 737; 1873.

If the fractured bone is completely severed from its connections, it would obviously be drawn downwards and inwards by the three muscles attached to it, the biceps, coraco-brachialis, and pectoralis minor. But in the recorded cases there appears, as a rule, to have been little displacement. This is due, no doubt, to the fact that the strong coraco-clavicular ligament has remained wholly or partially intact, and has kept the separated fragment from displacement. The symptoms which have been relied upon in diagnosing this injury are crepitus and increased mobility of the process, easily to be discovered by manipulation. There is no deformity about the shoulder, but, in some cases, impairment in the movements of the arm. The treatment consists in flexing the fore-arm on the arm, and bandaging the latter to the wall of the chest, with the elbow advanced to the front and raised, so as to relax, as far as possible, the muscles attached to the process. The arm must be kept in this position for a month. The union is frequently fibrous.*

Fracture of the Humerus.

For convenience of description, it is customary to divide fractures of the humerus into (A) fractures of the upper end; (B) fractures of the shaft; and (C) fractures of the lower end of the bone.

A. **Fractures of the upper end of the humerus.**—The different varieties of fracture of the upper end of the humerus may be classified as follows: (*a*) Fracture of the anatomical neck. (*b*) Fracture of the surgical neck. (*c*) Longitudinal or oblique fracture through the head of the bone, separating the greater tuberosity, or this process and a part of the articular surface. (*d*) Fracture through the epiphysial cartilage.

Fracture of the anatomical neck.—In

* Path. Soc. Trans., vol. xxxii., p. 155.

these cases the line of fracture is through the narrow and constricted portion just external to the articular surface, between it and the tuberosities of the bone. It appears in some cases to follow the line of attachment of the capsular ligament, in others to be a little above its insertion, and again in other cases, as Mr. Holmes has justly pointed out, the line of fracture runs partly through that portion of the bone external to the capsule, and partly through the joint itself. Fractures of the anatomical neck are usually classed as intracapsular fractures, but it is clear that only those cases where the line of fracture lies above the insertion of the capsular ligament can be properly denominated as such. The accident is a rare one,* much more uncommon than fracture of the surgical neck, and would appear to occur especially in old age, when the cancellous tissue in the interior of the bone has undergone partial absorption.

In most cases there is little or no displacement. The capsule remaining, at all events in part, attached to the lower fragment, prevents any great amount of deformity. The upper end of the lower fragment may be drawn towards the inner and front part of the joint by the action of the muscles attached to the bicipital ridges, but the amount of change in position is not great. In rare instances the separated head of the bone undergoes a remarkable alteration in position. Thus cases have been recorded where the capsule has been lacerated, and the head of the bone forced through the rent into the axilla; and Dr. R. W. Smith mentions a case where the upper fragment turned on its own axis, so that its cartilaginous surface rested against the broken surface at the upper end of the lower fragment. Hamilton records two other

* Mr. Hutchinson, though admitting the possibility of this fracture, doubts whether a true intracapsular fracture ever occurs (*Med. Times and Gazette*, vol. i., p. 359; 1866).

cases where the same thing occurred. As there are no muscles inserted into the separated fragment of bone, the displacement must be due either to the violence of the injury, or, as Hamilton believes, to a gradual displacement, in consequence of the movements of the parts.* In a large number of the cases of fracture of the anatomical neck of the humerus, the fracture is impacted, the upper fragment being driven into the lower. The head of the bone thus becomes wedged in between the two tuberosities, one or other of which are frequently at the same time broken off.

When the fracture is not impacted, the head of the bone may be entirely separated from all its surroundings, and one would be inclined to regard it as a foreign body, and fear that it would necrose from want of blood supply; and in some of our text-books on surgery we are told that such an accident *may* occur; but that it is exceedingly rare for such an occurrence to take place is proved by the investigations of Gurlt, who was unable to find a single authenticated case. The maintenance of the vitality is probably due to some portion of the capsule remaining attached to the head of the bone. This is especially liable to be the case at the lower part, where the fibres of the ligament are reflected from this point of attachment upwards to the margin of the articular cartilage (Treves).

The **causes** by which fracture of the anatomical neck is produced are always from direct violence, such as severe falls or blows on the shoulder.

The **signs** of the injury are not always very distinct, and differ as to whether the fracture is impacted or not. In the non-impacted fracture there is pain, and great swelling and bruising, due to the direct nature of the injury, about the shoulder. There is loss of motion in the arm, the patient being unable

* "Fractures and Dislocations," p. 193.

to raise it from his side. There is generally some slight irregularity about the shoulder, which, however, is soon obscured by the swelling, and the upper end of the lower fragment can sometimes be felt towards the inner side of the joint. Crepitus can generally be elicited, but not always, on account of the small size of the fragment, and the difficulty of fixing it. The diagnosis has often, therefore, to be arrived at by a process of exclusion. There are none of the characteristic signs of any of the various fractures about the shoulder joint, nor the ordinary signs of dislocation, and therefore by a negative process a correct diagnosis may be arrived at.

If the fracture is impacted, there is more deformity about the joint than in the simple fracture. There is slight shortening, though this is so slight as occasionally to be scarcely appreciable. There is some apparent projection of the acromion process, and flattening of the shoulder beneath, so that it has somewhat lost its rounded outline. There is no crepitus, unless, as frequently happens, one or other tuberosity has become separated, in consequence of the impaction, and then crepitus is easily felt by grasping the head of the bone and rotating the arm. The head of the bone can be felt in the glenoid cavity; but, according to Erichsen, is not in the axis of the limb.

Union is readily accomplished, sometimes by ligamentous tissue, but for the most part by bone, and even where the upper fragment has been rotated, as in the cases recorded by Smith and Hamilton, bony union has taken place. As might naturally be expected, the reparative process is chiefly accomplished by the lower fragment. This portion of bone, as Sir Astley Cooper first pointed out, throws out large quantities of callus, which embraces the upper fragment, and forms a cup-shaped cavity, in which it is received.

Treatment.—An endeavour must be made to remedy any displacement of the lower fragment by placing a pad in the axilla. The shoulder and upper arm are then to be enclosed in a carefully moulded guttapercha splint, and the arm bandaged to the side. Should impaction exist, no attempt must be made to disengage the fragments, but they must be allowed to unite in this position, the patient being at the same time warned that he must be prepared for a certain amount of deformity, and, as a consequence, impaired movement in the joint.

(*b*) **Fracture of the surgical neck of the humerus.**—The fracture in these cases takes place at the upper part of the shaft, between the tuberosities and the insertions of the teres major and the latissimus dorsi muscles. It is usually transverse in direction, but may be somewhat oblique. Like the fracture through the anatomical neck, it may be impacted or non-impacted, but the impacted fracture, unlike that of the previous injury, consists of an impaction of the upper fragment by the lower; the compact tissue of the upper part of the shaft of the bone being driven into the loose cancellous tissue of the head.

Causes.—This fracture is generally caused by direct injury, as from a blow, but cases are recorded where it has been produced by indirect force, as falls on the hand or elbow, and Hamilton mentions one case where it was produced by muscular action, *i.e.* throwing a ball. The displacement which takes place is two-fold. The upper fragment is carried outwards and rotated by the action of the three muscles which are inserted into the greater tuberosity of the humerus, the supraspinatus, the infraspinatus, and the teres minor. The upper part of the lower fragment is drawn inwards and forwards by the pectoralis major and teres major, and upwards by the biceps, triceps, coraco-brachialis, and deltoid (Fig. 28). But

this displacement is by no means constant, sometimes there is no displacement at all; sometimes the lower end of the upper fragment is displaced forwards, sometimes it has been displaced outwards and even backwards. These variations probably depend mainly upon the nature and direction of the violence and also on the direction of the line of fracture, and not upon muscular action.

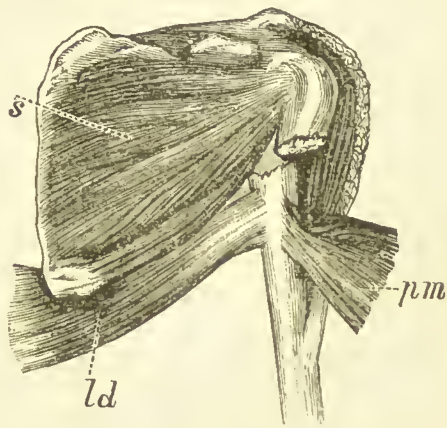


Fig. 28.—Fracture of the Surgical Neck of the Humerus.

The wood-cut shows the displacement which takes place from muscular action, in fracture of the surgical neck of the humerus. *pm*, pectoralis major; *ld*, latissimus dorsi; *s*, subscapularis. (After Hind.)

Symptoms. — The signs by which the ordinary non-impacted fracture is recognised are sufficiently obvious. There is considerable deformity about the shoulder, due to flattening of the deltoid, but this flattening is very different from what is seen in dislocation; there we have a projection of the acromion, presenting a prominent outline and a flattening immediately beneath it, whereas in fracture of the surgical neck there is not the same abrupt prominence of the acromion, but the point of the shoulder presents a more rounded outline and the flattening is some little distance below. The difference will be at once appreciated by reference to the accompanying figure (Fig. 29). There is shortening of the limb to the extent of about an inch. The head of the bone can be felt in its natural position, and will not be found to move when the arm is rotated. The upper end of the lower fragment can also be felt forming an irregular prominence beneath the great pectoral

muscle, and just below the coracoid process. This will be felt to move when the arm is rotated. There is great mobility, and crepitus is easily produced when the arm is extended. The axis of the limb is altered so that the arm projects from the side. The nerves of the brachial plexus are often irritated by the upper

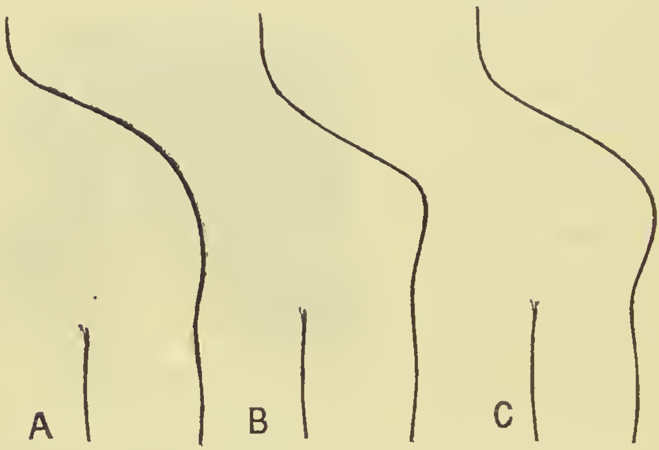


Fig. 29.—Flattening of the Shoulder in Dislocation and Fracture.

The wood-cut represents the outline of the shoulder in dislocation of the humerus and fracture of its surgical neck, with the different varieties of flattening which are produced. A, natural outline of the shoulder; B, outline of the shoulder in dislocation; C, outline of the shoulder in fracture of the surgical neck of the humerus.

end of the lower fragment, and pain shooting down to the fingers is complained of.

In impacted fracture of the surgical neck the symptoms are remarkably obscure and are almost entirely of a negative character. Dr. R. W. Smith has well summed up the means by which a diagnosis is arrived at. "When a person falls on the upper and outer part of the shoulders and at once loses the power of executing the motions natural to the articulation, when none of the characters of dislocation or of the ordinary fracture of the neck of the humerus are present, and when, at the same time,

there is a certain degree of deformity, which, though slight, it is by no means easy to remove, and an unusual difficulty in detecting crepitus, we have grounds for suspecting the existence of an impacted fracture of the neck of the bone." *

Crepitus is only to be obtained with difficulty by grasping the head of the bone with firmness, so as to fix it as completely as possible, and then rotating the elbow. Crepitus is generally to be produced in this way, because, as Smith has pointed out, "it rarely happens that the entire extent of the lower fragment has penetrated the head of the bone."

Treatment.—In order to successfully overcome the displacement in a fracture of the surgical neck, it is necessary to place a pad in the axilla, and bind the arm to the side, with the elbow carried well forward across the chest, by which the inward and forward displacement is overcome. By placing the hand only in a sling, the weight of the elbow drags upon the lower fragments and so overcomes the shortening. Some surgeons recommend a pad in the axilla and a guttapercha cap moulded to the outside of the shoulder, but this plan is not so efficacious in overcoming the displacement. Erichsen recommends a leather splint, about two feet long by six inches broad, bent in the middle to an acute angle, to be fitted to the axilla, so that one half rests upon the chest, and the other on the inner side of the arm. It is fastened in this position, and serves to correct the inward displacement. The hand only being placed in a sling, the weight of the elbow overcomes the upward displacement.

In both the intra- and the extracapsular fracture, especially the former, passive motion should be commenced early, so as to prevent, as far as possible, stiffness of the joint.

* Smith on "Fractures and Dislocations," p. 186.

(*c*) **Longitudinal or oblique fracture through the head of the bone.**—Some of these cases are commonly described as instances of separation of the greater tuberosity of the humerus, where there is an obliquely longitudinal fracture, separating the greater tuberosity, and it may be a small portion of the head of the bone. But, in addition to these, there exist cases in which, as was first pointed out by Guthrie,* there is a more or less oblique fracture, which separates the whole or the greater part of the articular surface of the humerus, together with the greater tuberosity, from the shaft and lesser tuberosity. Between these two extremes we may have the line of fracture running in any direction, and, according to its amount of obliquity, separating a greater or less amount of the head. Hence it seems advisable to describe all these cases in one group.†

The manner in which the accident is caused appears in most cases to be the same, and is the result of direct violence. It is produced by a fall, with violence, upon the anterior part of the shoulder joint, as in a fall from a horse, or from a scaffold. Some authors assert that the greater tuberosity alone may be broken off by the violent action of the three rotator muscles inserted into it, others believe that it only occurs as a complication of dislocation of the shoulder joint forwards.

When this fracture occurs, the displacement is two-fold. The greater tuberosity, with the portion of the head, of greater or less extent, connected with it, is drawn upwards and outwards by the three external rotators inserted into it, the supraspinatus, the infraspinatus, and the teres minor. The upper end of the lower fragment, consisting of the lesser tuberosity and

* *London Medical and Surgical Journal*, Nov. 9, 1833.

† *See* a paper on this subject by Dr. Ogston, *Lancet*, vol. i., p. 419, 1876; and also Smith on "Fractures," p. 176.

the remainder of the head, or it may be the whole of the head, is drawn inwards and upwards against the anterior and inner part of the capsular ligament. In this position it rests against the anterior margin of the glenoid cavity beneath the coracoid process, and is, in fact, partially dislocated. This displacement is produced by the combined action of the subscapularis, the muscles passing from the wall of the chest to the upper part of the shaft of the humerus and the anterior fibres of the deltoid.

Symptoms.—The deformity produced by this fracture is very great, especially if a considerable portion of the head of the bone has been separated with the greater tuberosity. The first thing which will strike the eye is the greatly increased breadth of the shoulder, together with a projection of the acromion process and a flattening of the deltoid beneath.

The prominence of the acromion is not, however, so great as in dislocation, nor does it present such an abrupt outline. Upon examination of the shoulder the increased breadth will be found to be due to the presence of two bony prominences, with a deep sulcus or groove separating them. One of these prominences will be found beneath, and sometimes a little internal to, the coracoid process. This is the lesser tubercle and the portion of the fractured head connected with it. It may be recognised by the fact that it will move under the fingers if the arm is rotated. The other prominence will be felt beneath the acromion process, on the outer side of the joint. This is the greater tubercle and the remainder of the head of the bone, which has been separated with it. It will vary in size according to the direction of the line of fracture, and will not be found to move during rotation of the arm. Crepitus is generally distinct, and is best elicited by drawing down the arm and rotating it, while the outer prominence is grasped by the finger and thumb

of the opposite hand. The patient is unable to move his arm to the horizontal position, but there is free mobility to the surgeon, especially if the examination be conducted under an anæsthetic. The elbow is carried away from the side, but can be easily approximated to it, and there is a slight degree of shortening in some cases, while in others there is none.

There appears to be in these cases, according to the observations of Guthrie and Ogston, a "marked impossibility of removing the deformity by any means whatever." This, Dr. Ogston conjectures, may be due to the "tendon of the biceps slipping into the cleft between the fragments." This hypothesis has never been verified by actual dissection.

Treatment.—In consequence of this inability to overcome the displacement entirely, union will take place with a certain amount of deformity, but in spite of this the movements of the arm appear to be but little impeded, and a useful limb may generally be anticipated. The endeavour of the surgeon must be to approximate as much as possible the broken fragments, and this is best done by extending the arm from the trunk and rotating it outwards. In order to carry out this treatment the patient must be laid on a hard flat bed, with a small pillow under his head only, and the arm must be carried away from the side, so that the hand is above the level of the patient's head, and the back of it resting on the bed. The limb must be fixed in this position by sand-bags. The position is necessarily exceedingly irksome to the patient, and should he object to it an attempt must be made, by means of a pad in the axilla and a second one over the greater tuberosity, to press the fragments together as much as possible; the joint being at the same time kept quiet by a guttapercha cap to the shoulder.

(*d*) **Separation of the upper epiphysis of**

the humerus.—This accident is said by some to be of not unfrequent occurrence. It has been well described by R. W. Smith, and his account appears to have been largely adopted in our text-books and elsewhere. It is generally the result of direct violence, as blows or falls on the shoulder.

Symptoms.—The principal sign, and one which at once strikes the eye, is the presence of an abrupt projection at the front of the joint some short distance below the coracoid process. This is the upper end of the shaft of the bone. The arm is directed downwards, outwards, and backwards, but the elbow can be approximated to the side. Upon examining the part, the head of the bone can be felt in the glenoid cavity, but it will not be found to move on rotating the arm. The projection in front presents a rounded, smooth, and convex surface, unlike the irregular sharp margin of a fracture, and will be felt to move with the movements of the arm. The deformity can be easily removed by extension, and at the same time pressing the prominence backwards and directing the elbow inwards; but speedily returns, when the extension is removed. During these manipulations a soft form of crepitus may be perceived, unlike, however, the ordinary crepitus produced by rubbing two bony surfaces together.

The treatment consists in endeavouring to maintain the fragments in position by means of pads and bandages, but some deformity will probably remain, generally, however, unaccompanied by any serious loss of motion. The injury unites by bone, and usually without any difficulty.

B. **Fracture of the shaft of the humerus.**—Fracture of the shaft of the humerus is a much more common accident than fracture of the upper extremity of the bone.

Causes.—The majority of cases of fracture of

the shaft of the humerus are produced by direct violence, as blows or kicks; some few by indirect violence, generally falls on the point of the elbow; and a few also by muscular contraction. The bone is also one which is commonly broken in intra-uterine fractures, or from force applied during parturition.

The shaft of the bone may be broken at any point, but fracture appears to be more common in the lower than the upper half of the bone. When it takes place from muscular action the line of fracture is generally about the centre of the bone, just below the insertion of the deltoid muscle. The fracture is usually somewhat oblique, and generally from above downwards and outwards. It may, however, take the opposite direction, or be transverse. In the latter case, often little or no displacement takes place. In the oblique fracture the alteration in position is often very great, the one fragment overlapping the other to the extent of an inch or more. The form of the displacement depends in a great measure on the direction of the force which inflicted the injury, and also on the direction of the fracture. Muscular action has, however, some influence in determining the direction of the displacement, especially in fractures occurring above the insertion of the deltoid muscle. When the fracture occurs in this situation the deltoid draws the upper end of the lower fragment upwards and outwards, so that it lies on the outer side of the lower end of the upper fragment, which is drawn inwards by the pectoralis major, the latissimus dorsi, and the teres major (Fig. 30). When the bone is broken immediately below the insertion of the deltoid, there is less displacement, since the counteracting forces of the muscles passing from the chest to the upper part of the shaft of the humerus on the inner side, and the deltoid on the outer, pretty nearly counterbalance each other. The more powerful action of the deltoid,

however, has sometimes the effect of drawing the upper fragment outwards, and it is at the same time tilted forwards by the combined action of the pectoralis major and anterior fibres of the deltoid. The lower fragment is drawn upwards, so as to overlap the other, by the triceps and biceps muscles. Fractures still lower down, where the bone gives attachment to the brachialis anticus in front and the triceps behind, are attended by very little displacement, since the fibres of these muscles are attached to both fragments.

Fig. 30.—Fracture of the Shaft of the Humerus.

The fracture has taken place just above the insertion of the deltoid, and the preparation shows the displacement which takes place from muscular action. The lower fragment has been drawn upwards and outwards by the deltoid, and the upper displaced inwards by the muscles forming the flaps of the axilla. (From a preparation in the museum of St. George's Hospital, series i., prep. 90.)

Symptoms.—The injured arm lies helpless by the patient's side, and he is unable to move it. There is pain, and often considerable swelling and bruising at the seat of fracture. The increased mobility in the continuity of the bone is most marked, for on attempting to raise the arm the bone at once bends at

the seat of injury. Crepitus can also readily be produced, so that the nature of the accident is at once detected.

As a rule fractures of the humerus unite readily, requiring from about thirty to forty days, but at the same time there is no bone more liable to ununited fracture.

Treatment.—As a rule the treatment of fracture of the shaft of the humerus is sufficiently simple. The fracture having been reduced, and the bone placed in good position, four short, well-padded splints are to be applied to the limb, and fixed in position by a couple of broad straps with buckles. The hand only should be supported by a sling, so that the weight of the elbow and lower fragment may keep up a certain amount of extension. In some cases, however, when the fracture is very oblique, and there is great shortening from muscular action, some further means is required to maintain extension and prevent deformity. The simplest plan appears to be to attach a weight to the elbow, which is allowed to hang by the side, or, if the patient be in the recumbent position, is suspended over a pulley. By this means any amount of extension may be made, according to the amount of the weight, and in this manner the deformity may be overcome.

In fracture of the shaft of the humerus the musculo-spiral nerve is occasionally injured by the broken end of the bone, or becomes involved in the callus, so that partial or complete paralysis of all the parts supplied by it results.

C. **Fracture of the lower end of the humerus.**—Fractures of the lower end of the humerus may be classified as follows: (1) Transverse fracture above the condyles; (2) fracture of either condyle; (3) fracture between the condyles into the joint, combined with transverse fracture; (4) separation of the lower epiphysis of the humerus.

(1) **Transverse fracture above the condyles.**—In these cases the fracture occurs in the lower part of the shaft of the humerus, where the bone is expanded laterally, and is very thin, and is external to the joint. It occurs often in young people, but is not uncommon at any period of life.

Causes.—The fracture is generally produced by indirect violence, from a fall on the elbow, while the arm is bent. In some few instances it has been caused by direct violence, as a severe blow, or kick from a horse. In one instance Hamilton traced it to a fall upon the hand. The fracture is generally transverse as regards its lateral direction, but oblique in its antero-posterior direction. The obliquity generally being from above downwards and forwards; occasionally, however, the line of fracture is reversed, and is directed from above downwards and backwards. Upon the direction of the fracture depends in a great measure the nature of the displacement. If the fracture runs, as it ordinarily does, from above downwards and forwards, the lower fragment is drawn upwards and backwards by the biceps and brachialis anticus in front, and the triceps behind (Fig. 31). If the fracture occurs in the opposite direction, the lower fragment is drawn upwards and forwards by the

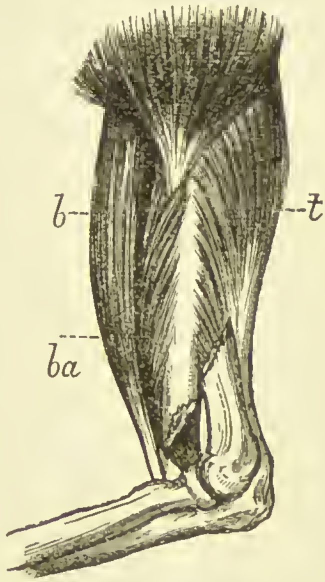


Fig. 31.—Fracture of the Lower end of the Humerus.

The figure shows the displacement which takes place from muscular action in fracture of the lower end of the humerus. *b*, biceps; *t*, triceps; *ba*, brachialis anticus. (After Hind.)

action of the same three muscles. Under these circumstances the upper fragment projects backwards beneath the triceps muscle.

Symptoms.—The diagnosis of this fracture is attended with a certain amount of difficulty, for on account of the similarity of the symptoms to dislocation of the bones of the fore-arm backwards, the one injury is very liable to be mistaken for the other; while the great and rapid swelling which takes place obscures to a considerable extent the relative position of the parts, and adds to the difficulty. There is great deformity about the part. The olecranon projects considerably, and there is a flattening or hollow above it. In front of the joint is an unnatural prominence caused by the lower end of the upper fragment. The fore-arm is slightly flexed on the arm, and the hand pronated. The movements of the elbow joint are considerably impaired, though not, as a rule, completely abolished. Flexion is especially imperfect, on account of the pressure of the lower end of the upper fragment into the bend of the elbow. Crepitus can generally be detected by extending the fore-arm, so as to bring the fractured ends into apposition. The signs principally to be relied upon in diagnosing the injury from dislocation are: the presence of crepitus; the easy reducibility of the deformity, and its speedy recurrence when the extension has been withdrawn; the normal relation of the internal condyle and the olecranon process to each other; the prominence of the lower end of the upper fragment rather above the level of the bend of the elbow, whereas in dislocation the lower articular surface of the humerus is below the level of the bend of the elbow, and the measurement from the acromion process to the external condyle, which is shorter than on the opposite side of the body in fracture, but is the same in dislocation.

In the more uncommon displacement of the lower fragment forwards and upwards the deformity differs; there is no prominence of the olecranon process, nor hollow above it; but, instead of this, the lower end of the upper fragment will be felt projecting backwards beneath the tendon of the triceps muscle; while in front and above the elbow joint, a considerable prominence will be plainly perceived, produced by the upper end of the lower fragment.

Treatment.—There is generally no difficulty in replacing the fragments by means of simple extension. After this has been done, the arm is to be put up in an anterior angular splint, with a second short, straight splint on the back of the arm. If there is any difficulty in overcoming the shortening, it is a convenient plan to insert a small pad between the fore-arm and the splint just *below* the bend of the elbow. The splints are first to be securely fixed to the upper arm, and the fore-arm being then flexed and bandaged to the angular splint, the pad acts as a fulcrum, and forces down the lower fragment.

Some surgeons recommend a posterior angular splint, and a short splint in front of the arm, with a pad between the limb and the splint to force back the lower end of the upper fragment. Others again recommend an internal angular splint, the hand to be put up midway between supination and pronation.

It must be remembered that this fracture is external to the joint, and, therefore, though there is a tendency for rigidity of the elbow joint to take place, it is not so great as in those cases where the fracture extends into the articulation. It must also be borne in mind that the early movement of the elbow joint is one of the causes to which failure of union is attributed (*see* page 84); it is probably better, therefore, to delay all attempts at passive motion until

about four weeks have elapsed, and a certain amount of consolidation of the fracture taken place.

2. **Fracture of the condyles** are fractures extending obliquely from either the outer or inner side of the lower end of the humerus, downwards into the joint, and separating either the outer or the inner condyle from the rest of the bone. Of these, Sir Astley Cooper, South, and others, believe that fracture of the internal condyle is the more common, while Malgaigne, on the other hand, regards its occurrence as rare; and if we believe, with R. Adams, that these fractures are produced by indirect violence, from falls on the hand, it would seem more probable for fracture of the external condyle to be the commoner form of injury, since the force of the concussion would be carried from the wrist mainly by the radius to this part of the bone.

Fracture of the external condyle.—The line of fracture in these cases extends from the external condylar ridge downwards and inwards into the joint, separating the capitellum from the rest of the articular surface of the lower end of the humerus. It may, however, vary, sometimes passing through the capitellum, at others extending more internally, and separating a part of the trochlear surface. This injury, according to R. Adams, is frequently met with in children from falls on the hand. He states that the connection of the radius with the ulna in early life is so loose that no resistance is afforded to the forcible ascent of the radius, when a sudden fall forwards on the palm of the hand occurs, and that the impulse carried along the radius is transmitted to the the capitellum and outer condyle of the humerus.* Hamilton, on the other hand, states that in a large majority of cases the fracture is produced by a direct blow.

The displacement is seldom great, the fragment

* "Cyclopædia of Anatomy and Physiology," vol. i., p. 68.

being forced slightly upwards and outwards, and inclined generally a little backwards.

The injury may be detected by the following symptoms: There is great pain and swelling in the situation of the injury, the swelling sometimes being so great that the external condyle cannot be distinctly felt. Pressure upon it will at once produce the sensation of crepitus. If the condyle can be felt, by grasping it with the finger and thumb, and moving it backwards and forwards, crepitus will be perceived, and this, together with the increased mobility of the fragment, at once establishes the diagnosis.

The movements of the elbow joint are impaired, and performed with pain.

Fracture of the internal condyle.—The line of this fracture usually extends from the internal condylar ridge, downwards and outwards, through the olecranon and coronoid fossæ to the middle of the trochlear surface of the humerus. The fracture is said to be always produced by direct violence. The displacement which occurs is upwards and backwards, and perhaps a little inwards, the ulna being displaced with it. So that when the fore-arm is extended on the arm, the ulna projects behind the humerus; when the fore-arm is flexed it returns to its natural position. The symptoms by which the accident is known are as follows: The internal condyle can be felt to be displaced, and, upon seizing it, increased mobility and distinct crepitus are at once perceived. When the arm is extended, in addition to the prominence of the ulna behind, the lower end of the humerus can be felt on the front of the joint. The breadth of the condyles is slightly increased, and the fore-arm is deflected to the ulnar side.

In both these injuries the fracture extends into the joint, and therefore the lesion is of a serious nature, since it is always attended with more or less

inflammation, and consequent impairment of the mobility of the articulation.

There is another fracture, first described by Granger,* affecting the internal condyle, which does not implicate the joint.

These are cases in which a small portion of the condyle is broken off; or possibly, as it generally occurs in young persons, in which the ossific centre for the internal condyle is separated from the rest of the lower epiphysis of the humerus. Granger states that this fracture is always produced by muscular action, but it seems more probable that in the majority of cases it is caused by direct violence. The displacement is due to muscular action, the fragment being drawn downwards by the muscles connected to it. The slight alteration in the position of the fragment, its great mobility and the presence of crepitus, together with impairment in the movements of the elbow joint serve to establish the diagnosis.

Treatment.—In treating these fractures an endeavour must be made to restore the fragment to its natural position by flexing the fore-arm on the arm and applying an angular splint. This may be supplemented by a pad over the displaced fragment, which will help to keep it in position. Passive motion must be commenced early, as there is great fear of permanent anchylosis. Hamilton recommends that it should be begun within seven days; Malgaigne and Sir Astley Cooper, about the end of the third week. There can be no doubt that, if it is delayed as long as this, there is great risk of permanent rigidity of the joint; and, with care, passive motion may be performed at a very early period, in these cases, without causing any alteration in the position of the fragment.

* *Edinburgh Medical and Surgical Journal,* April, 1818; vol. xiv., p. 196.

3. **Fracture between the condyles into the joint, with transverse fracture above the condyles.**—This is sometimes termed a T-shaped fracture, and is a complicated or exaggerated form of the preceding, since it is a separation of *both* condyles from the shaft of the bone, and also from each other. It occurs as the result of extreme direct violence on the back of the bone, and is often the consequence of gun-shot injuries, the fracture being more or less comminuted. The symptoms are pain, crepitus, mobility, and increased breadth from condyle to condyle. The injury is a serious one, being always followed by great inflammation and effusion into the joint, with permanent deformity and anchylosis. The treatment must be directed, in the first instance, to subduing the inflammation. The arm should be kept perfectly at rest, laid on a pillow, or lightly supported by an angular splint, and irrigation or cold evaporating lotions applied. After the swelling has subsided, the parts must be manipulated into as good a position as possible, and put up in an angular splint, in the most favourable position, with a view to anchylosis, since early passive motion cannot be employed in these cases, and permanent rigidity is likely to ensue.

4. **Separation of the epiphysis.**—Under this head two different forms of injury have been described. In the one, the articular portion of the humerus is alone separated, the condyles, which are ossified by distinct centres, remaining attached to the shaft of the bone; in the other, the condyles, together with the inferior articular extremity, are separated from the rest of the bone. The latter is the one which is usually believed to be the more common, though Dr. R. W. Smith believes that the former is the one which almost invariably occurs.* The signs which

* "Address in Surgery," *British Medical Journal*, vol. ii., p. 121; 1867.

characterise the lesion are such as to render it liable to be confounded with fracture above the condyles, or with dislocation of the bones of the fore-arm backwards. Mr. Hutchinson believes that it is much more common than is generally supposed, and that it is frequently mistaken for dislocation.* The fore-arm is flexed, and the hand in a position midway between supination and pronation. The olecranon projects posteriorly, and there is a prominence in front of the joint. In the disjunction of the entire epiphysis, which is ordinarily described, the prominent points of bone (the condyles above, and the olecranon and head of the radius below) are in their natural relation. In the partial disjunction there is a loss of the normal relation between the olecranon and condyles, and the measurement from the condyles to the styloid process of the radius and ulna respectively is diminished, as in dislocation. There is seldom any difficulty in reducing the deformity, but there is a great tendency for it to be reproduced, so that it is almost impossible to maintain the disunited surfaces in apposition, and union generally occurs with a certain amount of deformity. The treatment is the same as for transverse fracture, the elbow is to be flexed and fixed on an angular splint, with a short posterior splint. The motions of the joint after union are often much restricted; but, as Mr. Hutchinson says, great benefit will be obtained in time. "In the course of years, the end of the bone will become remodelled, until scarcely any trace of the lesion remains." †

Fracture of the Ulna.

The ulna may be broken in many situations. Thus the olecranon or the coronoid processes may be fractured; the shaft of the bone may be broken in any

* Pathological Society's Transactions, vol. xv., p. 199.
† *Op. cit.*, p. 200.

part of its course; and the styloid process may be separated from the rest of the bone.

Fracture of the olecranon.—This is by no means an uncommon accident, and generally occurs in adult life. It never occurs before the age of fifteen (Hulke). The injury is usually occasioned from direct violence; most commonly from falls on the back of the elbow while the fore-arm is bent at a right angle. It is also sometimes produced by muscular action, by the violent contraction of the triceps muscle during sudden extension of the arm.

The fracture may take place at any part of the process. A thin shell only may be torn off, and this is often the case in fractures produced by muscular action.

The most common situation, however, for the fracture is below the centre of the process, at the point where the epiphysis joins the shaft of the bone.

The line of fracture is in these cases for the most part transverse, but in some instances it has been noted to be oblique, in a direction from in front downwards and backwards, so that a portion of the posterior border has been separated with the process.

When the injury is occasioned by direct violence the fracture is sometimes comminuted, and when the violence has been great it is often compound.

The displacement is sometimes great, owing to the action of the triceps muscle; but in other cases there may be none. This occurs when the dense fibrous structures around the process are not torn.

Symptoms.—There is usually rapid swelling and contusion, so that when the surgeon is called upon to examine the patient, he will generally find a large, soft tumefaction at the back of the joint, which obscures to a great extent the olecranon process. On burying his fingers in this soft swelling he will be able to feel and make out the outline of the process, which,

in cases where displacement has occurred, will be found to be considerably above its normal position, with an hiatus or gap between it and the shaft of the bone. If now the fore-arm be flexed on the arm, this gap will be felt to be greatly widened, the process remaining stationary, and not following the movements of the rest of the bone. There will be no crepitus, unless, while the arm is extended, the displaced fragment be pushed downwards against the upper end of the shaft of the bone. If no displacement has taken place, and the fractured ends are in apposition, crepitus is at once elicited by grasping the olecranon with the finger and thumb, and moving it from side to side.

The union in these cases generally takes place by fibrous tissue. This is probably due to the great difficulty that there is in keeping the fragments in exact apposition. The union may, however, be bony. Though it is generally fibrous, patients, as a rule, recover with a useful arm, and enjoy perfect motion. But it must be remembered that in these cases the joint is injured, at all events in the majority of cases,* and, therefore, anchylosis is a frequent result of this injury. Non-union of the fracture is also not an uncommon complication.

In an interesting case, recorded by Mr. Jonathan Hutchinson, the olecranon on both sides of the body had been broken some time previously, from direct violence. On the right side there was no union, and as a consequence a wasted triceps and a useless arm. On the left side there was fibrous union and a useful arm.†

Treatment.—When the olecranon is much displaced, the plan of treatment originally recommended by Sir Astley Cooper is the best that can be adopted.

* In some cases where a thin shell only has been torn off the summit of the olecranon, the elbow joint need not necessarily be opened.

† *Lancet*, vol. ii., p. 158; 1871.

This consists in laying a strip of linen some inches in length longitudinally on either side of the fractured olecranon. A bandage (wetted, in order to prevent its slipping) is then to be applied to the arm immediately above the upper margin of the olecranon, and a second to the fore-arm. These bandages are to include the strips of linen. By now tying tightly together the ends of the strips, the bandages will be approximated, and the upper one will force down the displaced fragment until it comes in contact with the lower. An anterior straight splint is now to be applied to the fore-arm and arm, so as to keep the elbow extended (Fig. 32).

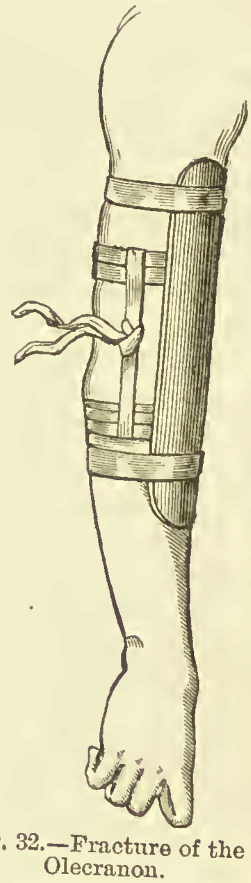


Fig. 32.—Fracture of the Olecranon.

The figure represents the manner of putting up a fracture of the olecranon. (After Sir Astley Cooper.)

If there is much swelling it is better to defer the application of these bandages for a few days until it has subsided.

Anchylosis is very liable to result from this injury, and if it does occur, the position in which the arm has been placed is most unfavourable; as anchylosis, with a straight elbow, renders the arm practically useless. At the same time, passive motion cannot be early commenced, since the frequent motion of flexion would have a tendency to separate the fragments. The plan, therefore, which I adopt, and which I believe can generally be undertaken without risk of separating the fragments is, at the end of three weeks, or

even earlier, to place the patient under the influence of an anæsthetic, and with the thumb firmly pressed on the top of the olecranon, to gently flex the elbow joint, and put it up on an angular splint. The manœuvre can usually be accomplished, if it be done with gentleness and care, without the slightest separation of the fragments, consolidation having so far taken place that the union is able to withstand the strain, and should anchylosis unfortunately result, the joint is now in the most favourable position, as regards the future welfare of the patient.

After the fracture is firmly united, passive motion must be commenced, and persevered in for a considerable time.

Should non-union occur, and the patient thereby be prevented from using his arm in his employment, and thus be debarred from gaining his livelihood, the pieces of bone should be wired together. This must be done under strict antiseptic precautions.

Successful cases are recorded by Sir William Mac Cormac * and by Sir Joseph Lister.†

In compound fractures, if the wound is small, the cases should be treated on Listerian principles. If the wound is large, and the bone comminuted, probably primary excision will yield the best results. The choice lies between anchylosis in the flexed position and excision, and the results of the latter operation are so favourable, in securing a useful limb, that it would seem better to submit the patient to the risk of the operation, rather than leave the joint to a more protracted recovery, and the certainty of anchylosis taking place.

Fracture of the coronoid process.—The subject of fracture of the coronoid process is one of considerable interest, on account of the difference of

* Clin. Soc. Trans., vol. xiv., p. 210.
† *Lancet*, vol. ii., 1883.

opinion which has existed as to its frequency. Most surgeons of the present day believe that the accident is one of great rarity, though that it does sometimes occur as a complication of dislocation of the bones of the fore-arm backwards is beyond doubt. Whether, however, fracture of the coronoid process can occur as a simple injury, uncomplicated by dislocation or fracture elsewhere, is a matter of extreme doubt, and, as far as I am aware, has never been verified by dissection.

Symptoms.—The signs which have been most relied upon in diagnosing this injury, when accompanied by dislocation, are displacement of the ulna, or both bones, backwards, the presence of crepitus, and the tendency of the luxation to return after reduction, as soon as the extension has been discontinued.

Sir Astley Cooper states that in a case under his care the ulna projected backwards, whilst the arm was extended; but when the fore-arm was flexed the deformity was removed.

Some surgeons have stated that the fragment was to be felt in front of the bend of the elbow, drawn upwards by the action of the brachialis anticus muscle. In the majority of cases, however, probably this would not occur on account of the manner of attachment of this muscle.

The symptoms of the injury, which have been given in the various detailed cases, differ considerably, and throw a halo of doubt over many of them; more extended knowledge from actual observation during life, verified by dissection after death, is required before they can be spoken of with any degree of confidence.

Treatment.—There can be no doubt as to the appropriate treatment of this injury, should it exist, or should its existence even be suspected. The only muscle which can have any influence in producing an

alteration in the position of the fragment is the brachialis anticus, and probably the amount of displacement produced by this muscle is very slight, on account of the manner in which it is inserted, its fibres being prolonged on to the shaft of the bone. By flexing the fore-arm, the points of attachment of this muscle are approximated, and the fragments brought into as near apposition as possible, should they have been separated to any great extent. The arm must, therefore, be placed on a right-angled anterior splint, and maintained in this position for about three weeks, when passive motion must be commenced.

Hamilton recommends that the splint should be discontinued at the end of seven to ten days, and a certain amount of motion permitted, believing that the future mobility of the elbow joint is of vastly more importance than the question of a bony or ligamentous union between the fragments. In most cases, whether passive motion is adopted early or late, a fibrous union must be anticipated, on account of the impossibility of completely approximating the fragments.

Fracture of the shaft of the ulna.—Fracture may occur at any part of the shaft of the ulna, but usually takes place about the middle of the bone, or a little below it, since this part is more exposed to the particular forms of injury from which this fracture arises. It is also more common in the lower half of the bone than the upper, the bone being here thinner and more fragile, and less covered and protected by muscles.

Causes.—The fractures are always produced by direct violence, and are said to occur often from violent blows in pugilistic encounters, the arm being raised to ward off blows from the face and receiving the full force of the injury. They are also frequently caused by falling, the bone striking against some prominent object, as the doorstep or curb-stone.

The displacement which takes place is mainly due to the force of the blow, and therefore it may take place in any direction. But the upper fragment may be drawn a little forwards by the action of the brachialis anticus muscle, while the lower fragment is abducted or carried outwards towards the radius by the pronator quadratus muscle. There can be, of course, no shortening or overlapping of the fragments, unless the radius is also broken or its head dislocated.

On account of the superficial position of its posterior border, fractures of this bone are very likely to become compound, either from the injury, from direct violence, lacerating the superimposed soft structures, or from the end of the displaced bone penetrating the skin. According to Hamilton, fracture of the ulna is frequently complicated with dislocation of the head of the radius.

Symptoms.—If displacement has taken place, the diagnosis of fracture of the ulna is comparatively simple, unless so much swelling has taken place as to prevent the surgeon tracing the outline of the bone. By carrying the finger along its subcutaneous border, the irregularity of the displaced fragment is at once perceived, and, by making pressure on the prominent point, crepitus is generally elicited. Should, however, no displacement have taken place, we must trust for our diagnosis to the fixed pain in the bone, bruising over it, increased mobility, and crepitus. This latter sign is best felt by placing the two thumbs one on either side of the painful spot and alternately pressing the two fragments; by this means the peculiar grating will be perceived.

Treatment.—After any displacement which may exist has been reduced, the treatment consists in applying two straight splints, one on the palmar, the other on the dorsal surface of the fore-arm,

and bandaging them in this position, while the hand is in a position midway between supination and pronation and the elbow flexed.

The styloid process of the ulna may be knocked off by direct violence and may be considerably displaced by the force of the blow. In these cases there can rarely be any doubt as to the diagnosis, the process being felt considerably displaced from its normal position. The treatment consists in gently manipulating the piece of bone into position and then encircling the wrist with a broad strip of adhesive strapping and placing the hand and fore-arm on a splint. Care must be taken that the sling in which the arm is placed does not press upon the fragment and reproduce the displacement.

Fracture of the Radius.

Fracture of the radius may take place at its head, neck, shaft, or lower extremity.

Fracture of the head of the radius generally occurs in conjunction with some other injury, and may consist in a longitudinal splitting through the head, or it may be broken up into many fragments. It appears to be a not uncommon complication of fracture of the coronoid process of the ulna and dislocation of both bones of the fore-arm backwards at the elbow joint, from falls upon the palm of the hand. That is to say, when the force of the injury has been sufficient to break the coronoid process, the head of the radius appears also to suffer. The only case of fracture of the head of the radius, as a simple uncomplicated injury, as far as I know, is one which occurred in St. George's Hospital, in a man who had fallen from a scaffold and who died from fracture of the base of the skull. After death, a vertical antero-posterior fissure was found running through the centre of the

head of the radius, separating one half of the cup-shaped cavity and a small portion of the shaft from the rest of the bone. There was no other lesion and the orbicular ligament was intact.

The symptoms by which the injury is diagnosed are loss of the power of supination and pronation; crepitus upon making these movements, and possibly displacement of the fragments, though unless the orbicular ligament is also lacerated, this could not occur.

Fracture of the neck of the radius is also an uncommon accident, as an uncomplicated injury, and one, indeed, of which Sir Astley Cooper doubted the existence. He states that he had never met with an example of it, and "if instances ever presented themselves, they must be very rare." Even should such an injury occur, on account of the large mass of muscles by which the neck of the bone is surrounded, it is exceeding difficult to arrive at an accurate diagnosis, especially in a position where so many fractures may occur; as it is impossible to exactly localise the spot from which crepitus, if there be any, proceeds. Thus cases have been recorded where it has been believed that this injury has taken place, and further investigation, or it may be the examination of the part after death, have proved that the diagnosis was wrong.

Should fracture of the neck of the radius occur the biceps would draw the lower fragment upwards and forwards. Thus we should expect to find a bony projection at the front of the elbow joint. In addition to the projection at the front of the joint, the fore-arm is pronated, all power of pronation and supination is lost, and crepitus is perceived by fixing the head of the radius and alternately supinating and pronating the hand.

The treatment consists in relaxing the biceps muscle by flexing the fore-arm on the arm and putting

the limb on an angular splint. If there is much forward displacement of the lower fragment, it may be corrected by a pad placed over the prominent bone, between the limb and the splint. In these cases care must be taken in commencing passive motion, lest the biceps, no doubt shortened by the flexed position in which the fore-arm has been maintained, should pull on the lower fragment and thus displace the bones before they have become firmly consolidated.

Fractures of the shaft of the radius.— Next to the clavicle, the radius is more frequently broken than any other bone in the body; a large proportion of these cases are, however, fractures of the lower end; still, the shaft of the bone, on account of its exposed situation on the outer side of the fore-arm, and since it receives more or less entirely all shocks transmitted from the hand, is very liable to be broken. Thus fractures of the shaft of the radius may be produced either by direct or indirect violence, *i.e.* falls on the hand. Though in this latter form of injury, fracture of the lower end is more likely to occur than fracture of the shaft, nevertheless the latter injury does undoubtedly occur.

The fracture may take place at any part of the shaft of the bone, but for convenience of description it is advisable to consider them: (1) as fractures occurring above the attachment of the pronator radii teres, and (2) below the attachment of this muscle. When the fracture is in the former situation, above the insertion of the pronator radii teres and below the insertion of the biceps, the upper fragment is acted on by this latter muscle and the supinator brevis, and is thus fully supinated and at the same time drawn forwards and flexed at the elbow joint by the biceps; at the same time the lower fragment is in a state of extreme pronation and drawn inwards towards the ulna by the

two pronators. Thus an extreme displacement, not producing any great deformity, takes place; the upper fragment being in a condition of supination, the lower of pronation. If such a fracture is put up in the ordinary position, midway between supination and pronation, it will at once be seen that a very serious evil will result, the fracture will unite with the upper fragment fully supinated and the lower one in the mid-position and thus a union will take place which must affect the movements of the hand. The patient recovers with great loss of the power of supination, so that he is obliged to effect this motion by an awkward rotation of the shoulder.

When the fracture is below the insertion of the pronator radii teres, there is not the same amount of evil to contend with; the action of the biceps and supinator brevis as supinators is neutralised by the pronator radii teres, which is also in these cases connected with the upper fragment, so that this portion of the bone is generally maintained in a position midway between pronation and supination. The lower fragment is also not so strongly pronated, since there is only one muscle, the pronator quadratus, to act upon it, and the action of the muscle is neutralised, though perhaps feebly, by the supinator longus. The displacement which occurs is that the upper fragment is drawn forwards by the biceps and pronator radii teres and towards the ulna by the latter muscle; while the lower fragment is drawn inwards towards the ulna by the pronator quadratus, assisted by the action of the supinator longus, which, by pulling on the styloid process, tilts the upper end of the fragment inwards (Fig. 33). It is in these cases that we have to guard against union of the broken ends to the ulna by callus thrown out across the interosseous space.

Symptoms.—The diagnosis of these fractures is not usually attended with any difficulty. There is

fixed pain in the part, increased mobility, loss of power of rotation, and crepitus. The latter is best elicited by fixing the head of the bone with the thumb and rotating the hand, or by alternately pressing the fragments with the fingers placed on either side of the point of the suspected fracture.

Treatment.—When the fracture is situated above the insertion of the pronator radii teres, in order to secure the proper position of the fragments it is necessary to put the fore-arm up in a condition of full

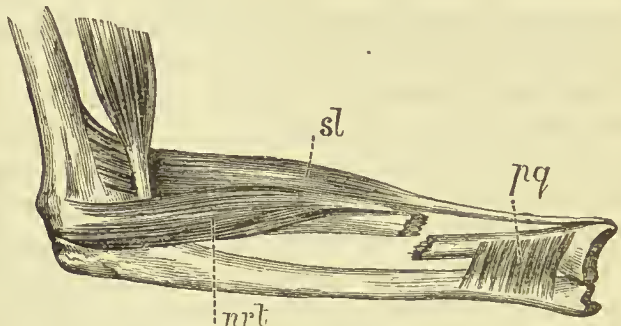


Fig. 33.—Fracture of the Radius.

The figure shows the displacement which takes place from muscular action in fracture of the radius at the junction of the middle and lower third of the shaft. *prt*, pronator radii teres ; *pq*, pronator quadratus ; *sl*, supinator longus. (After Hind.)

supination, so that the two fragments may unite in their proper axis, as first suggested by Lonsdale. The only manner in which this can be effectively accomplished is by confining the patient to bed, with the arm extended and resting on a pillow, when the hand rests easily on its back. Few patients, however, will consent to this plan of treatment for what they regard as so trivial an injury as fracture of one of the "small bones of the arm." The matter ought, however, to be fairly laid before them, and they ought to be warned that if they do not adopt this plan of treatment it is at the risk of the loss of some of the movements of the hand. The alternative plan of treatment consists

in applying a posterior angular splint to the arm and fore-arm, while the hand is in a state of supination, and fixing the fore-arm and splint to the side of the body so that the elbow projects a little behind, and the hand, with the palm uppermost, in front of the trunk. This position is also irksome and inconvenient to the patient, but seems to be preferable to adopting the usual plan of laying the fore-arm across the chest and permitting a certain amount of pronation; though it is just to state that some surgeons consider "that it answers well for all ordinary cases." * Mr. Callender says that the requisite position may be "easily maintained by the use of ordinary side splints provided with firm angular pads, the angle of each pad being adapted to fix the distal end of the radius into the requisite position.†

When the fracture is situated below the insertion of the pronator radii teres, the position midway between pronation and supination, which is most agreeable to the patient, may be adopted. Two short side splints, one on the palmar, the other on the dorsal aspect, are to be applied, but as there is a tendency for the broken ends to fall inwards towards the ulna, a pad should be placed in the centre of the splint, down the front of the fore-arm, so as to keep the bones apart and guard against this evil.

Fracture of the lower end of the radius (*Colles's fracture*).—This fracture is one of extreme frequency. In the tables compiled by Mr. H. Morris in Mr. Hulke's article in the "System of Surgery," out of 1,084 fractures treated at the Middlesex Hospital during ten years, 169 were fractures of the lower end of the radius. Of these, 114 occurred in females and 55 in males.

It takes place most frequently in advanced life,

* Holmes; "Principles and Practice of Surgery," p. 245.
† St. Bartholomew's Hosp. Reports, vol. i., p. 298.

though occasionally occurring in the young, and more often in the female than the male.

The line of fracture is generally situated about an inch from the lower articular surface of the radius, for the most part being rather under than over this measurement. Colles puts it at one and a half inches; Smith states that it is never more than an inch. Gordon, from an examination of twenty-seven specimens, states that the line of fracture varied posteriorly from $\frac{3}{8}$ to $1\frac{3}{4}$ inch, and anteriorly from $\frac{1}{4}$ of an inch to two inches.

If a vertical section be made through the lower part of the radius, it will be seen that the compact tissue of the shaft of the bone, at about one inch from the lower extremity, becomes rapidly thinner, to merge into an exceedingly thin layer which covers the cancellous tissue of the expanded end of the lower extremity of the bone. The compact tissue, therefore, at this point presents on section a wedge-shaped appearance, and it is immediately below this that fracture usually takes place. Here the bone is evidently weaker than elsewhere, not only on account of the sudden thinning of the compact tissue, but also because of the unequal density of the compact and cancellous tissues which meet at this point. There is, however, a slight bend, with the convexity backwards, in this situation, which tends to strengthen the bone, by giving it the best direction for receiving forces transmitted to it by falls upon the hand.

The fracture is usually described as being transverse, and, no doubt, for the most part this is true as regards the lateral direction, though even in this direction it may be slightly oblique. But in the antero-posterior direction I have in a considerable number of cases noted a marked obliquity, the fracture passing from below upwards and backwards. This is opposed to the observations of Dr. Gordon,

who, from the measurements quoted above, would imply that the obliquity was in the opposite direction, so that the line of fracture runs from the anterior surface of the bone downwards and backwards. The manner in which the fracture is produced points rather to the probabilities of the fracture running from in front upwards and backwards, than in the direction suggested by Dr. Gordon.

The displacement which occurs in this fracture is three-fold. (1) The lower fragment is displaced backward and a little upwards. (2) It is rotated backwards through a segment of a circle, the centre of which is a transverse line drawn through the upper end of the lower fragment, so that the inferior articular surface is directed backwards as well as downwards. (3) Owing to the strong radio-ulnar ligaments which confine the inner extremity of the lower fragment, this portion of bone also undergoes a partial rotation through a circle, the centre of which is the radio-ulnar articulation, and its radius a line drawn from this point to the styloid process of the radius (Fig. 34).

It is difficult to understand how this triple displacement can be produced by any other cause than the force of the injury driving the bone into this position. The accident is always the result of falls upon the outstretched hand;* when a man falls in this position the hand is pronated and extended; the ligaments and tendons at the front of the wrist are stretched, the elbow is driven in by the weight of the body and the leverage is exerted on the bone; the palmar surface first, then the cancellous tissue, and finally the dorsal surface. The whole shock is,

* Dr. T. Chiene believes that Colles's fracture occurs in consequence of falls on the hand, when the angle formed by the axis of the arm and the ground is less than 60°, generally about 45°. When at the moment of impact the angle is greater than 60°, then the result is usually a sprain of the wrist or dislocation at the elbow (*Edinburgh Med. Journ.*, p. 1106; June, 1874).

therefore, borne by the lower end of the radius, which is broken off, and then by a continuance of the force in the direction of the falling body is displaced upwards and backwards. In consequence of the shape of the articular surface of the radius and the direction of the force, the greater stress of the impulse is received on the posterior border of the inferior surface of the

Fig. 34.—Fracture of the Lower end of the Radius.

The lower fragment is much displaced backwards and upwards, and is also rotated backwards, and has united in this position. The preparation was removed from a patient who died about eleven weeks after a fall of about twenty feet, having sustained other serious injuries. (From a preparation in the museum of St. George's Hospital, series i., prep. 103.)

radius, and thus the rotation of the lower fragment backwards is produced. From the position of the hand, in a state of extreme pronation, the ball of the thumb receives principally the force of the fall, and to the radial edge of the bone is transmitted the shock from the ball of the thumb; this, combined with the fact that the inner side of the fragment is more fixed by the strong radio-ulnar ligaments, causes the displacement to be more extensive on the side of the styloid process, and occasions the rotation of the fragment in the arc of a circle, the

centre of which is situated at the radio-ulnar joint, and of which mention has been made.

Some surgeons believe that the displacement is due to muscular action alone; but there is one very strong argument against this theory, and that is, that several cases have been recorded where the patient has fallen on the *back* of his hand, producing a fracture of the lower end of the radius. In these cases the displacement has been *forwards*, instead of backwards as it ought to have been, if it was due to muscular action.

In this fracture the displacement is not sufficiently great for the one fragment to clear the other, and, therefore, the compact tissue of the broken end of the upper fragment penetrates the cancellous tissue of the lower end. As Callender expresses it, "The radius is first broken, then, by the momentary continuance of the force in the direction of the falling body forwards and outwards the shaft is driven into the carpal end, burying itself chiefly from the dorsal surface towards the palm."

Very different views have, nevertheless, been taken of this matter. Gordon believes that impaction is impossible; and R. W. Smith that, as a rule, no such penetration with fixation takes place. Certainly the examination of united specimens of this fracture would seem to favour the contrary view; for, in most cases, where recovery with deformity has taken place the compact tissue on the posterior surface of the upper fragment appears to be embedded in the cancellous tissue of the lower end. This R. W. Smith explains, by stating his opinion that it is due to deposit of new bone in the angle between the two fragments, and, therefore, on the outside of the shaft of the old bone, and "that it is impossible to establish the theory of impaction, unless it can be shown to maintain in cases of recent fracture." This has been done by

Callender, who records three cases of fracture of the lower end of the radius, in which the patient died of other injuries, and in which he had the opportunity of dissecting the parts shortly after the occurrence of the accident. In all three cases the shaft of the bone was impacted in the cancellous tissue of the lower end.* Moreover, the symptoms during life, the immobility of the fragments, and the absence of crepitus, until extension has liberated the fragments, point to impaction.

It seems to me, therefore, that it must be conceded that, at all events in the majority of cases, the upper fragment is driven into the lower and becomes either impacted and fixed, or else the lower extremity of the bone is broken in two or more pieces, or variously comminuted so that no fixation takes place. More extended observation and dissection of recent cases is required before the question can be regarded as definitely settled.

Symptoms.—The symptoms of this injury are so marked that it may generally be recognised at a glance. The patient will be noticed to support the injured limb with the sound one, the body being inclined to the affected side, and the hand maintained in a position midway between supination and pronation. The fingers are bent, and on the back of the wrist is a projection which rises above the level of the carpus and terminates in a sudden hollow. The projection is more marked on the radial side of the forearm. On the anterior surface, corresponding to the dorsal prominence, is a well-marked sulcus, and above it a projection gradually shading off on the surface of the fore-arm. The styloid process of the ulna is remarkably prominent, and the hand is directed to the radial side. The patient complains of much pain and the movements of supination, and pronation

* St. Bart.'s Hosp. Reports, vol. i., p. 284.

are lost. There is usually no increased mobility of the bone and no crepitus, but after extension has been made and the deformity reduced both these signs become apparent. Whenever preternatural mobility exists, in the first instance, it indicates, I believe, comminution of the lower fragment and is, therefore, to be regarded as an unfavourable sign, as likely to complicate the treatment and to lead to a less favourable result than if this symptom were not present.

These fractures, as a rule, unite readily, but are very liable to be followed by a certain amount of stiffness and impairment of motion, even though the fragments have been carefully replaced and there is no deformity remaining. This is particularly apt to occur in old persons, and is due mainly to effusion taking place along the sheaths of the tendons, and a matting together of these structures and surrounding tissues. So that it is often months before the hand and fingers regain their normal movements. Sometimes where considerable interlocking of the fragments takes place, it is impossible to disengage them, and recovery then takes place with a permanently stiff and deformed limb.

Treatment.—As regards the treatment we have to consider two points: (1) the restoration of the fragments to their normal state, and (2) their retention in this position.

(1) As regards the reduction of the fracture, opinions differ both as to its difficulties and its manner of accomplishment. Some believe that, at all events in certain cases, the fragments are so interlocked that reduction is impossible and the deformity is permanent; others believe that it can be accomplished with ease and certainty; others, again, assert that though reduction is easy the displacement is sure to recur. Probably the truth consists in the fact that cases differ; that in some the impaction is so great that it will be

found impossible to disengage the fragments, while in others where there is less impaction this can be easily accomplished. When the lower fragment is extensively comminuted the deformity may recur after reduction; or it may be that the deformity has not really been overcome but only appears to have been so, and to this may be attributed the idea that the deformity has recurred.

The fracture can generally be reduced by extension with the hand supinated and adducted as much as possible.

Professor Macleod recommends that the ulnar side of the patient's wrist should be placed on the surgeon's knee, which acts as a fulcrum. By then "taking hold of the patient's hand and alternately flexing, extending, and drawing it to the ulnar side, while the thumb of the surgeon's disengaged hand is made to press the lower fragment directly into its place," reduction is accomplished. Some authors believe that the periosteum on the dorsal surface of the fragment is untorn, and that this is the greatest opponent to reduction. Should any difficulty, therefore, occur, extension should be made while the hand is in an hyper-extended position, which will serve to relax this membrane. Others again teach that the difficulty in reduction is due to the implication of the head of the ulna in the tendon of the flexor carpi ulnaris muscle and the annular ligament, and that this must be remedied before reduction can be accomplished.

(2) After the fractured ends have been placed in apposition any tendency to a recurrence of the displacement must be overcome by mechanical means. The apparatus used are of various kinds. Nelaton's pistol-shaped splint is the one which is perhaps more generally employed than any other, and in most cases its use appears to be followed with good results. It consists of a wooden splint, curved so as to resemble a

pistol, which is firmly fixed to the fore-arm and hand, so that the latter is kept well drawn over to the ulnar side, while a second short splint is applied to the opposite surface of the fore-arm. Most authors who have written on this subject recommend that the pistol splint should be applied to the dorsal surface of the fore-arm; but I certainly agree with the American surgeons, that its application to the palmar surface is

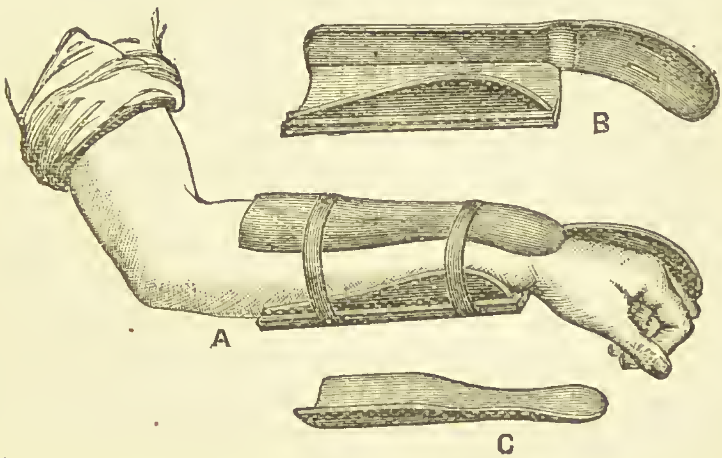


Fig. 35.—Gordon's Splint for Fracture of the Lower end of the Radius.

B, The palmar splint; C, the dorsal splint; A, the two splints applied to the fore-arm

more advantageous and comfortable to the patient, and in my own practice have always adopted this plan.

Some surgeons prefer two straight splints with pads arranged so as to press the lower fragment into its place. By this means the hand is left entirely free, and the fore-arm only being supported in a sling, the hand is adducted by its own weight and thus makes a certain amount of extension on the lower fragment. By this plan also the fingers can be exercised, and thus much of the stiffness of the wrist and fingers avoided.

Dr. Gordon believes that in Colles's fracture both of the broken ends are displaced forwards, and that

therefore the natural concavity of the radius forwards is lost. He has therefore devised an apparatus with which he proposes to remedy this defect. It consists of a palmar splint (Fig. 35 B), to the anterior surface of which a conical piece of wood is fixed, so that the external border projects beyond it, this presses on the lower end of the upper fragment and raises it; while the position of the hand elevates the lower fragment. A dorsal splint (Fig. 35 C), more thickly padded over the wrist than the fore-arm, is also applied, and the splints held in position by webbing. The pressure of the webbing is thrown entirely on the ulnar side of the fore-arm in consequence of the projecting border of the anterior splint, and therefore depresses the prominent end of the ulnar.*

Carr's splint has lately also been extensively adopted. It consists of a palmar splint, padded to fill up the convexity of the radius, with an oblique cross bar attached to its extremity, on which the metacarpo-phalangeal joints rest and the fingers are flexed over it. This is secured with a bandage and a second dorsal splint applied.

The only apparatus which Pilcher recommends is a broad strip of adhesive plaister around the wrist, and a sling to support the arm.

In the after treatment passive motion must be commenced early. After about the twelfth to the fourteenth day the fingers should be freed daily from the splint, flexed, and extended. This may be done without moving or interfering in any way with the fracture. And at a later period, about the end of the third week, passive motion should be commenced and systematically carried on in the wrist joint.

Fracture of the lower end of the radius may

* *See* an interesting paper on this splint by Mr. Lawson Tait, in which he compares it to a "dermal skeleton"; *Med. Times and Gaz.*, Feb. 17, 1866.

occur without displacement, and may be either transverse or comminuted. In these cases there is pain and helplessness, but no deformity. Crepitus may be present or absent. Or the displacement may occur in the opposite direction to that which usually takes place in a Colles's fracture. This is usually produced by falls on the dorsum of the hand, as was the case in an instance recorded by Mr. Callender, where the man fell with his arms under him, so that the hand, bent to the extreme of flexion, was crushed under him.*

Separation of the inferior epiphysis of the radius occasionally occurs in subjects under the age of twenty, and may be mistaken for Colles's fracture, which it resembles in the existence of a dorsal swelling.† The deformity is, however, very different; for in disjunction of the epiphysis the displacement is directly backwards, and there is none of that rotation which takes place in the fracture, so that there is no appearance of obliquity, and the radial border of the fore-arm does not present the curved outline as in Colles's fracture. The injury assumes, therefore, more of the appearance of dislocation of the carpus backwards, but can be distinguished from it by the fact that the styloid processes of the radius and ulna are in their normal relation to the bones of the hand, and that they move with this part of the body when any motion is imparted to it.

Fracture of both bones of the fore-arm is by no means an uncommon injury, and is produced both by direct and indirect violence. Of these the fractures from direct injury are the more common.

* St. Bart.'s Hosp. Reports, vol. i., p. 289. *See* also Smith on "Fractures," p. 162.

† Mr. Hutchinson says: "It is not an uncommon accident, and occurs in children, where Colles's fracture would occur in the adult."

When indirect force is applied to the fore-arm as a rule the radius only suffers, but in some instances both bones may give way. Malgaigne has recorded a case in which fracture of both bones appeared to occur from muscular contraction taking place in a man while digging. This seems, however, to be an isolated case, no other instance of a similar lesion having been, as far as I am aware, recorded. The fracture usually takes place somewhere about the middle of the shafts of the bones, but if it is produced by direct violence it may occur at any part; more often, however, in the lower than in the upper half of the bone, on account of the greater exposure of the lower half to injury, and the protection of the upper half by the mass of muscles by which it is almost surrounded.

The fracture is usually transverse, but may be oblique, in which case there is more tendency to over-riding of the fragments. The amount of displacement is very various, both as regards direction and amount. In some cases there may be little or no alteration in position; in others, extreme displacement, with overlapping of the fragments and great shortening of the limb. The direction of the displacement also varies much, and appears to follow no definite rule. Both fragments may be displaced so as to form an obtuse angle with each other, either forwards, backwards, or to one side. Or the lower fragments only may be displaced, either forwards or backwards, so as to overlap the upper fragments. Or one bone only may be displaced, its broken ends being bowed either towards or away from the opposite bone.

Fracture of the lower end of the radius and ulna sometimes, though rarely, takes places. As a rule, it occurs from falls on the hand, and, therefore, the force of the blow is principally sustained by the

radius, and a Colles's fracture is produced ; the ulna may, however, give way, and a double fracture occur. It is of importance to differentiate this injury from fracture of the radius alone, as the displacement is somewhat different. The lower ends of the upper fragments are drawn together by the pronator quadratus, which is frequently lacerated by the ends of the bones. The radius is thrown into a state of

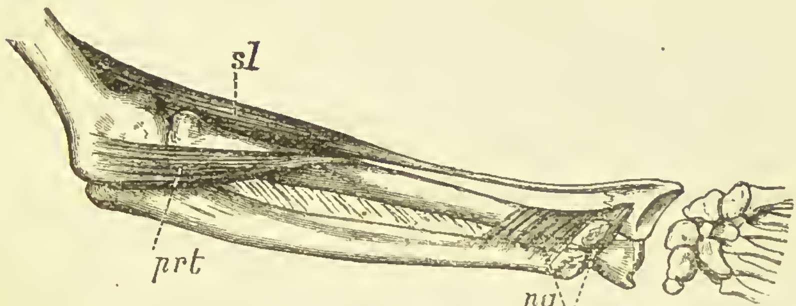


Fig. 36.—Fracture of both Bones of the Fore-arm just above the Wrist. The figure shows the displacement which takes place from muscular action in fracture of the lower end of both radius and ulna. *prt*, pronator radii teres ; *pq*, pronator quadratus ; *sl*, supinator lougus. (After Hind.)

pronation by the pronator radii teres. At the same time the lower fragment of the radius is drawn upwards by the supinator longus (Fig. 36).

Symptoms.—The diagnosis of this injury is usually comparatively simple. There is great pain, and complete loss of power in the limb. Where there is displacement there is considerable deformity, and perhaps shortening. Crepitus is usually easily obtained, and this, with the increased mobility of the fragments, is at once sufficient to point out the nature of the injury.

Treatment.—If there is any displacement it must be overcome by extension from the wrist, the hand and fingers being flexed so as to relax, as far as possible, the muscles ; counter-extension being made at the same time at the elbow by an assistant,

with the fore-arm bent upon the arm. Occasionally the displaced fragments may be pushed back into their proper position by the direct pressure of the thumb of the surgeon on the prominent bone while extension is being maintained, and sometimes a gentle movement of pronation and supination, during extension, will facilitate the reduction of the fragments. After the broken ends have been brought into proper apposition, they are to be maintained there by two straight splints, one on the anterior, the other on the posterior surface of the limb. If the fracture has taken place below the middle of the fore-arm, that is to say, below the point of insertion of the pronator radii teres into the radius, the limb may be put up in a position midway between supination and pronation. This is the most comfortable for the patient, and fulfils the further indication of keeping the two bones wide apart, so that there is little fear of their becoming united across the interosseous membrane. And owing to the antagonistic action of the pronator radii teres to the biceps and supinator brevis, there is not any great amount of supination of the upper fragment, and, therefore, less chance of the two bones uniting in a condition of different degrees of rotation and of loss of some of the power of supination, When, however, the fracture has taken place in the upper half of the bone the unopposed action of the biceps and supinator brevis strongly act upon the upper fragment of the radius, and produce a condition of supination in this part of the bone, so that the only plan by which a good result can be obtained is by putting up the limb with the hand supinated, so that the lower fragment is rotated outwards into the same condition of supination as the upper one. This is to be accomplished, as recommended in fractures of the radius (page 205), by a posterior angular splint on the front of the fore-arm.

In treating these fractures care should be taken that the splints are somewhat wider than the limb, so that the bandage which encircles them shall not make any lateral pressure on the bones.

Union usually takes place in about thirty to thirty-five days, but is occasionally delayed, and in some instances non-union may occur; sometimes in one bone, sometimes in both. The radius is more often the seat of non-union than the ulna.

Perhaps there is no other part of the body in which the surgeon should be more alive to the liability of the occurrence of gangrene after fracture than in the fore-arm. This was long ago pointed out by Roux, and is explained in many cases, I think, by the position in which the limb is placed. It is well known that when the fore-arm is forcibly flexed on the arm the circulation is entirely arrested. A less degree of flexion will, of course, retard the flow of blood through the brachial artery to a certain extent. When this is taken into account, together with the superficial position of the two main arteries of the fore-arm in a part of their course, and their liability to be compressed by the pressure of the splint, it will be evident that the amount of blood supplied to the limb must be very considerably reduced. When, now, there has been a severe injury and a great effusion of blood further pressing upon the vessels and retarding the circulation, it will be easy to understand how gangrene takes place from deficient supply of blood to the part.

Fracture of the Carpal Bones.

The bones of the carpus, being jointed together by a considerable extent of surface and united by strong ligaments, so that a certain amount of movement is permitted between the several bones, are able to withstand a considerable degree of force, and are

little liable to fracture, except from extreme violence, when the parts are so comminuted that amputation becomes necessary. The bones are, however, occasionally fractured by severe blows or falls on the wrist, or by the passage of heavy weights, as cart-wheels, over the part.

In these cases, as a rule, there is little displacement; the fragments are held in place by the numerous ligaments which pass from one bone to another, and there are usually few symptoms beyond the loss of movement, pain, swelling, and bruising which exist, with possibly crepitus. The treatment consists in keeping the hand perfectly quiet on a splint, and applying cold evaporating lotions. There will in all probability be some permanent rigidity about the wrist.

Fracture of the Metacarpal Bones.

Fracture of one or more of the metacarpal bones is a by no means uncommon injury, resulting for the most part from direct blows, but also occurring in some cases from indirect violence, as blows with the clenched fist, or falls upon it.

According to Hulke, the first metacarpal bone is the one most frequently fractured, and this is what one would expect from its more exposed position and greater extent of motion. After this the second is most commonly fractured, then the fifth and the fourth; the third being the one which least frequently suffers.*

The fracture is generally transverse, or slightly oblique, and is attended with a displacement of the proximal end of the distal fragment backwards, so that the head of the bone projects into the palm of the hand. This is probably due to the natural curve of the bone, assisted, it may be, by the action of the interossei muscles.

* "System of Surgery," vol. i., p. 969.

The symptoms are generally well marked. The irregular outline of the bone on the dorsum of the hand, the projection of the head in the palm, with pain, bruising, and crepitus, are sufficient to indicate the nature of the lesion. The injury is one which is liable to be overlooked, principally on account of the patient regarding his injury as a severe bruise only, and neglecting to seek advice. There is rarely any difficulty, if the patient is seen shortly after the injury, in overcoming the deformity by means of extension. All that is then necessary is to place a pad in the palm of the hand so as to fill out the concavity of the bone, and apply an anterior splint. Sir Astley Cooper recommends that the fingers should be flexed over a ball placed in the palm of the hand and fixed with a bandage in this position. And Malgaigne recommends two pads, one under the head of the bone, the other over the dorsal prominence; these are to be kept in their places by two broad splints, one on the anterior, the other on the posterior surface of the limb.

Fracture of the Phalanges.

From their exposed position these bones are not unfrequently broken, and the fractures are very often compound. Simple fracture may and does, however, frequently occur, generally from direct violence. The fracture is in most cases about the middle of the bone, and is easily diagnosed.

The treatment consists in moulding a leather or guttapercha splint to the finger in an extended position. The fracture, as a rule, unites readily, and the splint may be left off and passive motion commenced at the end of the third week.

CHAPTER IV.

FRACTURE OF THE PELVIS.

INJURIES of the pelvic bones are usually severe, and of grave importance; not so much, perhaps, on account of the danger involved in the fracture itself, but of the risk to life which arises from the contents of the pelvis being involved in the mischief.

They may be conveniently divided, for purposes of description, into fractures of the false and true pelvis.

Fractures of the false pelvis.—These may vary much in extent, and as a rule involve little or no danger. It occasionally happens that the anterior superior spine of the ilium may be chipped off, or a portion of the crest may be broken through, or the fracture may traverse the whole length of the ala of the ilium, or this portion of bone may be extensively comminuted and the fragments displaced (Fig. 37). This latter fracture is the result of some extreme crushing violence, and may be complicated with fracture of the true pelvis; or, without the true pelvis being broken, the case may be complicated by injury to the intestines which lie in the hollow of the bone.* Fractures of the false pelvis are usually produced by direct violence, but may occur from muscular action. Severe blows, the fall of a heavy weight or masonry on the body, buffer accidents, or being run over, are among the more common causes of fracture from

* Mr. Holmes records a case of fracture, where the whole of the fæces were discharged through a wound on the outer side of the right buttock, presumably from an injury to the cæcum. The patient recovered ("Principles and Practice of Surgery," p. 219).

direct violence. When the bone is broken from muscular action it is generally one of the spinous processes which is torn off.*

Symptoms.—The nature of the injury is usually apparent. The patient complains of great pain in the part, especially increased by putting the abdominal muscles into action, by making any violent expiratory effort as coughing or sneezing. There is usually considerable swelling and bruising from the direct violence which has produced the fracture. Upon pressing with the hand against the crest of the ilium it will be felt to be very movable, and distinct crepitus will be easily elicited by seizing the crest and moving it to and fro. It is well not to carry the investigation too far, lest some injury is inflicted upon the viscera by the movement of the fragments; but as they are less closely connected with the false than the true pelvis, such an accident is less likely to occur in these cases than in

Fig. 37.—Fracture of the Innominate Bone.

The left innominate bone extensively fractured. The iliac portion has been broken into three fragments, which are much displaced. The pubic portion presents one fracture running across its horizontal ramus, and another at the junction of the rami of the ischium and pubes. (From a preparation in the museum of St. George's Hospital, series i., prep. 122.)

* *See* cases in *Brit. Med. Journal*, vol. ii., p. 513, 1872; and *American Journal of Medical Sciences*, p. 277, June, 1871.

those of which mention will be made directly. As a rule there is little deformity, and the fracture unites readily, and without giving rise to any serious defect. All that is necessary is that the patient should be laid on his back in bed, with the shoulders raised and a pillow under his knees, in order that the thighs may be somewhat flexed on the pelvis and the muscles relaxed. Some surgeons recommend that the lower part of the abdomen should be swathed in a rib roller or flannel bandage. But such treatment is unnecessary, and may be harmful, since the pressure of the bandage has a tendency to depress the fragment out of its proper position.

Fractures of the true pelvis.—The most common situation in which fracture of the true pelvis takes place is through the horizontal ramus of the pubes and the ascending ramus of the ischium, thus traversing the obturator foramen (Fig. 37). A consideration of the bony ring of the pelvis at once points this out as the weakest part. Fractures may also occur near the sacro-iliac joint or symphysis pubis. When the fracture occurs through the horizontal ramus of the os pubis and the ascending ramus of the ischium, it not unfrequently happens that the fracture is double or multiple; the same injury occurring on both sides of the body, so that the whole of the central part of the pelvis is separated from the rest of the bone. Or it may be that fracture occurs in this situation on one side, and a fracture near the sacro-iliac joint on the other.

It is in these fractures of the bony ring of the pelvis that injury of the viscera is likely to occur. The urethra is most commonly wounded, and less frequently the bladder,* with consequent extravasation of urine; the rectum, vagina, small intestines, and even

* *See* a *résumé* of twenty cases of fracture of the innominate bone *Lancet,* vol. ii., p. 346; 1865.

the uterus, may also be injured by a displaced fragment.

Causes.—Fractures of the pelvis are commonly produced by falls, blows, or foreign bodies passing over or compressing the pelvis, and may be caused either by direct or indirect violence. When the pelvis is compressed from in front, in an antero posterior direction, the fracture occurs from *direct* violence; when the force is applied to the side, in a transverse direction, the two acetabula are pressed together and the bone gives way at its weakest part from indirect violence. In both cases, if the force is continued, the greatest strain after the fracture has occurred is thrown on the portion of the ring in the neighbourhood of the sacro-iliac joint, in the one instance because the force tends to separate the two iliac bones, and in the other because it tends to push them together. This accounts for the frequency of the double fracture above alluded to. When the patient falls, alighting on his feet or ischial tuberosities, the ring gives way at its weakest part from indirect violence.

Symptoms.—The signs by which this injury may be recognised are usually of a well-marked character. There is the history of a severe injury and the patient is collapsed. There is great pain complained of in the region of the pelvis, especially upon moving or coughing. There is often considerable bruising and swelling in the neighbourhood, and, it may be, some laceration of the skin. The patient is quite unable to stand, and if he attempts to do so, has a feeling as if the body were falling to pieces. Upon grasping the two iliac bones and moving them upon each other, great mobility of the bones will be felt, and crepitus will be elicited. Care must be taken in conducting this examination, since the pressure of the surgeon's hand may displace a fragment and cause

some injury to the pelvic viscera. After the surgeon has once thoroughly satisfied himself of the presence of crepitus, all further examination should be interdicted. Occasionally, from the inability to obtain crepitus, the diagnosis of fracture of the innominate bone is somewhat obscure. There is also sometimes difficulty, when crepitus is felt, in localising it and distinguishing whether it is due to fracture of the neck of the femur or the bones of the pelvis. The plan advocated by Mr. John Wood is the most convenient for distinguishing between these two conditions. "The surgeon must grasp the femur with one hand, and place the other firmly upon the anterior superior iliac spine or crest, or upon the pubes. Then on moving the femur and abducting it freely, if a crepitus be detected it will be felt the *most distinctly* by that hand which rests on or grasps the fractured bone." *

If any injury of the internal organs has taken place the collapse will be more pronounced, and there will be special symptoms indicating the nature of the lesion. If the bladder or urethra has been wounded, there is blood in the water, perhaps inability to pass it, and other symptoms of this injury. If the rectum or vagina has been pierced there will be bleeding from these passages, and the fragment of bone may sometimes be felt by introducing the finger. If the small intestine has been injured, symptoms of peritonitis will speedily show themselves, and the case, in all probability, rapidly prove fatal.

Treatment.—The main indication for treatment is perfect rest. If any portion of bone can be felt manifestly out of position, an endeavour must be made by manipulation to restore it to its normal place. Thus a fragment may be felt from the rectum or vagina, and the patient being under the influence of an anæsthetic, its reduction may be accomplished

* *Lancet*, vol. ii., p. 347 ; 1865.

by the finger introduced into these passages. The patient is to be laid on a firm bed, and great support will generally be felt by the application of a broad flannel roller round the pelvis, or by a belt firmly buckled in the same position. This supports the pelvis, and serves to keep the fragments in apposition, and there is not the same risk here, as in fractures of the false pelvis, of the pressure of the bandage causing displacement of the fragments.

The bowels must be kept open and a catheter used if necessary.

The patient must be kept as quiet as possible for about six weeks, after which a little movement may be allowed, but it will be some time longer before he will be able to stand or walk without support.

FRACTURE OF THE ACETABULUM.

The acetabular cavity may be fractured in two situations; either a portion of the rim may be broken off, or the fracture may take place through the basin of the cavity, and may be a simple fissure traversing it, or a comminuted fracture, causing a large opening into the pelvic cavity through which the head of the bone may protrude. Occasionally the fracture follows the line of union of the three portions of which the innominate bone consists in early life, constituting a Y-shaped fracture.

Fracture of the lip of the acetabulum.—This form of fracture is usually produced by falls, in which the head of the femur is forcibly driven against the innominate bone; hence it is generally the upper and back part of the rim which is broken off, and the head of the bone, now receiving no support in this situation, may slip on to the dorsum of the ilium or into the sciatic notch. The symptoms are therefore those of luxation, but with this difference; that when the dislocation is reduced, which generally

çan be done without any difficulty, there is a great tendency for the deformity to be reproduced. Crepitus also will generally be felt during the act of reduction. The limb will be found to be shortened and inverted and the prominence of the trochanter to be lost.

The great difficulty in the treatment of these cases is that of maintaining the head of the bone in its proper place, and a certain amount of shortening and consequent lameness is almost always the result of this injury. The treatment consists in restoring the limb to its proper shape by means of extension, and then applying a long splint with a well-padded perineal band before the extension is relaxed. Constant vigilance is required, as, in spite of the extension, the head of the bone will oftentimes be found to have become again displaced, and if allowed to remain in this abnormal position very great shortening and deformity will be the result, with permanent lameness.

Fractures through the base of the acetabulum may or may not be accompanied by displacement of the head of the femur. That is to say, if there is a simple fissure across the cavity, the head of the bone will remain in its natural position; if, on the other hand, the basin of the fossa is extensively comminuted the head of the bone may be driven inwards and project into the pelvic cavity (Fig. 38). If there is no displacement, the signs are very obscure; crepitus may or may not exist, and there are no other symptoms which would lead us to more than a conjectural diagnosis. But when the head of the bone has been driven inwards, the symptoms are more marked, and to a certain extent resemble dislocation, for which this accident has been frequently mistaken. The limb is shortened, there is loss of prominence of the trochanter, and the limb partially flexed and adducted. In some cases the toes have been inverted, in others

everted, and again in others there has been neither inversion or eversion. There appears, however, in these cases to be a greater amount of mobility than in dislocation. In a case recorded by Professor Smith the patient had the power of everting, abducting, and flexing the limb.* Probably also crepitus would be felt on moving the limb.

Fig. 38.—Comminuted Fracture of the Acetabulum.

The floor of the acetabulum has been driven inwards towards the pelvic cavity, causing an extensive gap. Starting from this point is a complicated fracture, which divides the ilium into two portions and separates it from the rest of the innominate bone, and also separates the pubes from the ischium. Taken from the body of a man who fell eight feet on to the left buttock. (From a preparation in the museum of St. George's Hospital, series i., prep. 123.)

In most of these cases the injury is so severe, and the violence that has caused the fracture is so great, that other lesions are produced also, and the patient usually succumbs.

Treatment. — An attempt may be made under chloroform to disengage the head of the bone and restore the natural length of the limb, though it is probable that such a proceeding will not be attended with any great amount of success, nor is it wise to persevere in it too long. The limb must be put upon a long splint, with a perineal band to keep up extension, and the

* *Dublin Quarterly Journal*, vol. xxxv., p. 174.

treatment conducted on exactly the same principles as for fracture of the neck of the thigh bone.

Fracture of the Ischium.

Fracture of the ischium alone is a very rare form of injury. It generally, when it occurs, implicates the *tuber ischii,* and is usually produced by falls from a height when in a sitting posture. Malgaigne was able to collect six cases. The diagnosis is often difficult, but crepitus can generally be felt by grasping the tuberosity and moving it from side to side.*

Fracture of the Sacrum.

The sacrum is not often broken, on account of its thickness and strength, and its protected and deep-seated position. When fracture does occur in this bone it is usually at the lower part, where it may be broken from kicks, blows, or, in fact, any form of direct violence. The fracture is often complicated by injury to the nerves of the sacral plexus, leading to loss of power and sensation in that part of the lower extremity supplied by these nerves; paralysis of the sphincter ani muscle with incontinence of fæces and retention of urine. † The lower fragment is drawn forwards, in some cases by the great gluteal and the coccygeus muscles, and may press upon the rectum, causing obstruction in this canal.

The symptoms by which the injury may be recognised are the deep-seated pain and bruising following a direct blow on the part; an irregularity in the outline of the bone, to be detected by running the finger down the sacral spines, and crepitus. This latter sign may sometimes be elicited by introducing the finger into the rectum and pressing

* *See* cases by Devatz, *Union Médicale de la Gironde,* Decembre, 1866, 1867; and Weedon Cooke, *Lancet,* vol. i., p. 570; 1860.

† *See* two cases by M. Mercier; *L'Union Médicale,* No. 115; 1860.

upon the coccyx and lower part of the sacrum, which will sometimes be felt displaced forwards upon the upper fragment and encroaching on the bowel.

The treatment consists in replacing, as far as possible, the lower fragment with the finger introduced into the rectum. This can generally be accomplished with ease, but there is often considerable difficulty in retaining the fragment in position, and box-wood cylinders, bags stuffed with lint, and metal tubes have been introduced into the bowel to make pressure on the bone and keep it in position. None of these plans have proved very efficacious, and the better and simpler treatment appears to be to lay the patient on his back, with a cushion under the upper part of the sacrum, so as to prevent pressure on the loose fragment, and then by means of careful dietary and opium prevent his bowels from acting. This, as Dr. Hamilton has pointed out, accomplishes two ends. It keeps the muscles connected with the lower end of the rectum quiet, and so prevents them from displacing the bone; and secondly, the accumulation of hardened fæces in the rectum acts as a pad pushing back the lower piece of the sacrum and keeping it in position.

In addition to simple fracture of the sacrum, this bone may also be broken, in any direction and at any part, in those injuries which break at the same time the other bones of the pelvis. Such an injury is always produced by extreme violence, and is of such an extensive nature that patients rarely recover.

Fracture of the Coccyx.

On account of its mobility the coccyx is not often broken, though this accident does occasionally occur from kicks or falls upon some hard projecting body. It has been said also to have been broken during parturition. Probably, in some of these cases, the

injury has been a separation of the coccyx from the sacrum, and therefore ought more properly to be regarded as a luxation. The two injuries are, however, so nearly identical that it is more convenient to regard them as one, especially since it frequently happens that, in the so-called luxations, a thin shell of bone is torn away with the interposed fibro-cartilage, and the lesion does not therefore actually occur at the joint. There is in this injury great pain, especially in sitting, walking, or in defæcation. By introducing the finger into the rectum, the diagnosis can at once be established. If the lower fragment has been displaced forwards, as it usually is, the base of the coccyx is felt projecting into the rectum ; if, on the other hand, the displacement is backward, the apex of the sacrum is felt producing a prominence in the same situation. In both instances there is an unusual projection into the rectum, and increased mobility and crepitus felt by grasping the bone with the index finger in the canal and the thumb on the back of it. The crepitus is of course absent in cases of true luxation of the coccyx from the sacrum, and this would serve to establish the diagnosis between the two injuries. The treatment consists in reducing the fracture or dislocation, as the case may be, by pressure and counter-pressure from the rectum and the surface of the body, and keeping the patient in the recumbent position until union has taken place. The bowels should be restrained from acting for as long as possible, and it is a wise precaution to administer an enema before the reduction of the displacement, so as to completely empty the rectum.

CHAPTER V.

FRACTURES OF THE LOWER EXTREMITY.

Fracture of the Femur.

Fracture of the thigh bone is an accident of very frequent occurrence. Perhaps, after the clavicle, there is no single bone which is so commonly broken as the femur. The fracture may occur in any part of the bone, but, for convenience of description, it is customary to divide them into fractures (1) of the upper end; (2) of the shaft; and (3) of the lower end.

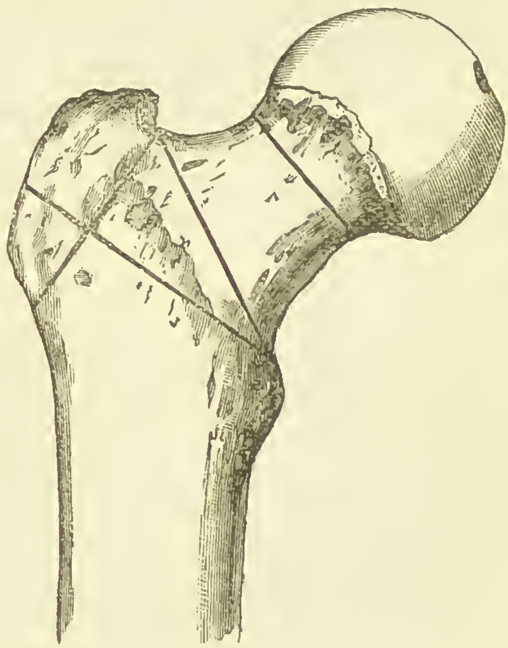


Fig. 39.—Diagramatic Sketch of the Fractures of the upper end of the Femur.

The lines represent the most common direction of the ordinary fractures of the neck and upper extremity of the thigh bone.

Fractures of the upper end of the femur.—These are divisible into (α) fracture of the neck of the femur; (β) fracture at the junction of the neck with the trochanter; (γ) fracture of the great trochanter; and (δ) separation of the epiphyses, either of the head of the bone or of the great trochanter (Fig. 39).

a. **Fracture of the neck of the femur.**—The solution of continuity in these cases generally takes place at the junction of the head with the neck of the bone, but may occur in any part of the neck. It is, therefore, always, to a certain extent, within the capsule, and is generally entirely within the limits of the attachment of this ligament. The fracture is therefore frequently termed the "intracapsular" fracture of the neck of the femur. It is, for the most part, transverse, or only slightly oblique in direction (Fig. 40), and may be impacted or non-impacted. Impaction, however, is not nearly so frequently present in this fracture as in the one immediately to be described, where the solution of continuity takes place at the junction of the neck with the trochanters. When impaction does occur, the neck of the bone is, as a rule, driven into the soft cancellous tissue of the head, or there may be mutual impaction; or, in other cases, the line of fracture may be irregular or dentated, and the two fragments may be dovetailed into one another.

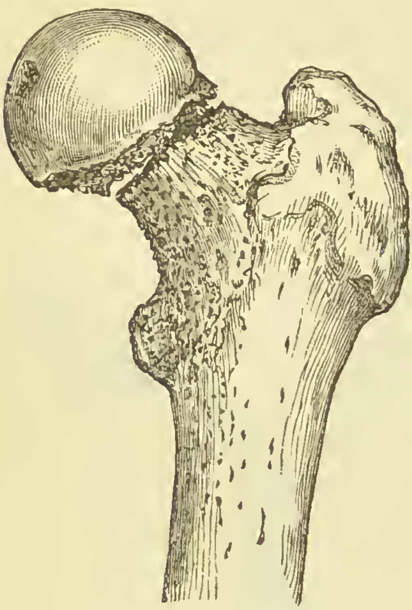


Fig. 40.—Intracapsular Fracture of the Neck of the Femur.

The fracture has taken place close to the junction of the neck with the head of the thigh bone, and is entirely within the capsule. (From a preparation in the museum of St. George's Hospital, series i., prep. 180.)

Causes.—It can be scarcely possible, except from a gun-shot injury, to produce intracapsular fracture of the neck of the femur from direct violence, from the manner in which it is surrounded and protected by

muscles, and from the depth at which it is placed. Accordingly, we find that these fractures are produced by indirect force, such as falls on the feet or trochanter, or from a wrench or twist. It is essentially a special injury of advanced life, when a sudden twist or strain on the part, produced by some trivial cause, such as slipping off the curb, or catching the toe in some inequality in the ground, causes the patient to stumble, and the bone gives way, the patient falling as a consequence of the fracture. The fracture may also be caused by the patient falling on the knees; the force of the blow on the lower end of the bone causes it to give way at its weakest part, the neck. According to M. Rodet, when the force acts vertically, as in falling on the knees, the fracture is oblique; when, on the other hand, the force acts from before backwards, as in a sudden strain thrown on the part in endeavouring to save the body from falling, the fracture is transverse. The liability of the aged to this injury arises from several causes, from the alteration in the position, structure, and shape of the head and neck of the femur in persons of advanced age. In the adult male, the angle which the neck forms with the shaft is obtuse, but as age advances it tends to diminish, so that in very old subjects its direction becomes horizontal, and the head sinks below the level of the trochanter. In the adult female the angle is never so obtuse as in the male, but approaches more nearly a right angle. Hence the changes in the obliquity of the neck appear more marked in this sex, and this, no doubt, is one of the reasons why fracture of the neck of the thigh bone is more common in the female than the male. In old age the cancellous tissue of these parts becomes degenerated, the cells enlarged and loaded with fat, and the compact structure much thinned. According to Dr. Merkel, there is in old persons an absorption of that process of the

cortical substance which runs between the lesser trochanter and the under part of the head, and which he calls the "calcar femorale." This process, he asserts, sustains the greatest amount of pressure when the body is in the erect position.*

In consequence of this degenerated condition of the bone, and the slight force required to produce its solution of continuity, these fractures are sometimes subperiosteal, under which circumstance there is little displacement. If the periosteum is torn through, the amount of separation of the fragments depends upon the extent to which the reflection of the capsular ligament is lacerated. It will be remembered that at the point of attachment of the capsular ligament to the neck of the femur, the innermost fibres are reflected from their insertion, along the neck of the femur, to the articular cartilage. Where these fibres are only partially torn, the intact portion serves to retain the fragments, to a certain extent, in apposition, and there is only slight separation and consequent shortening of the limb. When, however, they are completely torn through, the displacement is much more considerable; in some instances being so great that one or other fragment has lacerated the capsular ligament and protruded from the joint.

The displacement in this fracture is mainly due to the alteration in position of the lower fragment, which is drawn upwards, and, at the same time, rotated outwards. The upward displacement is produced by the action of the glutei, and by the rectus femoris in front, and the hamstring muscles behind. The eversion appears to be partly due to muscular action, and partly to the weight of the limb, which, in consequence of the line of gravity falling through the outer side of the thigh, has a tendency to fall outwards when muscular action is suspended.

* *Brit. Med. Journal*, vol. ii., 1873; p. 544.

According to Bigelow, the posterior aspect of the neck, where the compact tissue is thinner and more brittle than in front, is more extensively crushed and comminuted in fracture of the neck, and therefore tends to favour eversion. The muscles which are concerned in rotating the lower fragment outwards are the small external rotators attached to the great trochanter, assisted by the psoas and iliacus, pectineus, adductors, and gluteus maximus; but it is difficult to understand how they can have much action in rotating the femur outwards after their centre of motion has been destroyed by the fracture of the neck of the femur; their contraction would rather have a tendency to draw the bone backwards.

Symptoms.—The signs by which a fracture of the neck of the thigh bone within the capsule is to be recognised are, (1) alteration in the shape of the hip; (2) in the direction of the axis of the limb; (3) shortening; (4) pain; (5) possibly crepitus.

1. Alteration in the shape of the hip. This is mainly due to general flattening and an alteration in the position of the trochanter major, which is approximated to the crest of the ilium. This displacement can be verified by three different measurements. (*α*) By Nélaton's line, *i.e.* a piece of tape stretched from the anterior superior spine of the ilium to the most prominent part of the tuber ischii, which in the natural condition just touches the trochanter major; in fracture of the neck of the femur lies some distance below it. (*β*) By Bryant's test,* which consists in carrying a horizontal line round the body, through the two anterior superior spinous processes of the ilia, and then measuring the vertical distance between the top of either trochanter and this line. (*γ*) By Morris's bi-trochanteric measurement,† which consists

* *Lancet*, vol. i., p. 119; 1876.

† "System of Surgery," vol. i., p. 1003. 3rd edition.

in measuring the distance, from the median line of the body, of a perpendicular line drawn through the top of the great trochanter, and comparing it with the same measurement on the opposite side of the body. This proceeding gives the amount of inward displacement, and may be usefully employed in conjunction with Bryant's test, which denotes the amount of upward displacement. The trochanter is also sunken, and does not appear to be as prominent and defined as in the natural condition. It can be felt to move on rotating the thigh, but does not describe a segment of a circle, as it can be felt to do on the uninjured limb.

2. There is an alteration in the direction of the axis of the thigh. In most cases the whole limb is everted; the thigh is slightly flexed on the pelvis, and the leg on the thigh; so that, as the patient lies in bed, the whole limb is turned outwards, and rests on its outer side in a remarkably characteristic and apparently helpless condition.

Inversion of the limb in cases of intracapsular fracture has been occasionally noticed. The cause of this is not very clear, but probably depends upon the direction in which the original force was applied.

3. The *shortening* in cases of fracture within the capsule rarely exceeds an inch, often not being more than half this amount. The degree of shortening depends in a great measure upon the amount of laceration of the reflected portion of the capsular ligament. In some cases, where this is only slightly or not at all torn, no shortening exists.

A remarkable feature in the history of fractures of the neck of the thigh bone is the fact, that though the shortening may be very slight; so slight, indeed, as to be scarcely noticeable immediately after the injury, some days later considerable shortening may either suddenly occur, or the limb may become gradually and slowly

shortened. The causes of this are several. It may happen that the fibrous investment of the neck, as mentioned above, may be untorn, and the surgeon in his endeavours to make out crepitus may cause laceration of this structure, and so produce this condition. Sudden shortening may also take place some time after the occurrence of fracture, from fragments, which were originally impacted or interlocked, becoming separated.

Gradual shortening may ensue from stretching of the capsular ligament; from the muscles, which have been, to a certain extent, paralysed from contusion at the time of the accident, recovering their action under the influence of rest, and gradually exerting their power in displacing the fragment; or, lastly, from rapid absorption of the neck of the bone, which sometimes takes place after injury to it.

4. The pain in fracture of the neck of the thigh bone is, as a rule, slight, unless upon any movement of or pressure upon the joint.

5. Crepitus is by no means a constant symptom of fracture of the neck of the thigh bone within the capsule. Its absence is partly due to the softened and fatty condition of the bones, which may be rubbed on each other without producing the peculiar grating which is felt in a healthy bone, and partly to the fragments being separated so much from each other that crepitus cannot be obtained unless the limb is well drawn down at the same time that it is rotated, so as to bring the fractured surfaces into apposition.

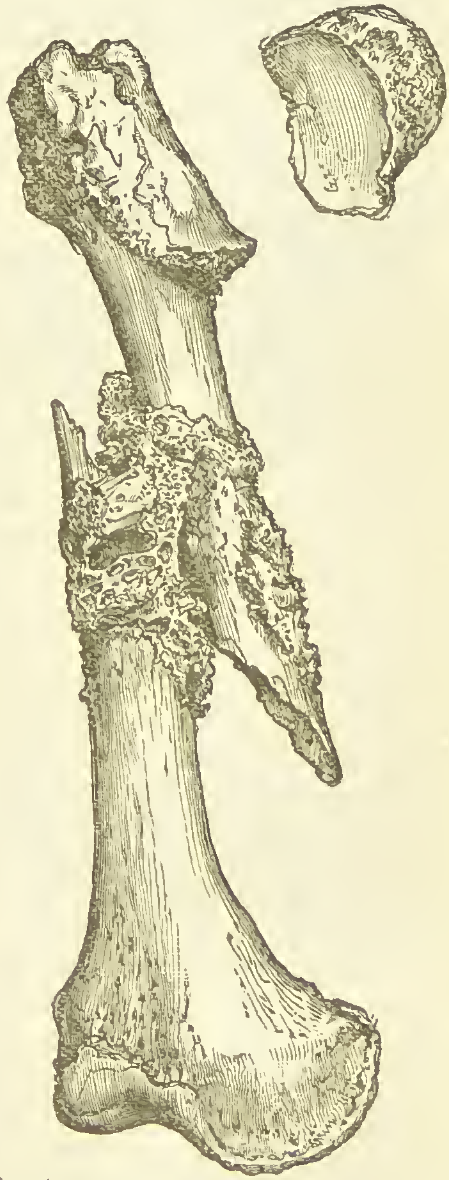
Fracture of the neck of the thigh bone may be mistaken for mere contusion of the hip, and in those cases where the fragments remain in contact with each other, the diagnosis is by no means easy, and such a case might readily be mistaken for contusion, until, in consequence of the movements of the patient, or from some accidental cause, the fragments become

displaced. Under ordinary circumstances, the absence of all the characteristic signs, except the loss of motion, in cases of contusion renders the diagnosis easy. In some cases, it is said, interstitial absorption of the neck of the femur follows a simple contusion of the hip. If this is true, it would be impossible, some time after the injury, to know that a fracture had not taken place. From dislocation there is usually no difficulty in the diagnosis, the presence of eversion and the free mobility of the limb are sufficient to settle the point; while in those cases where the limb is inverted, the absence of the head of the bone from the buttock, and the much greater amount of movement which is possible, will distinguish it from dislocation. The constitutional disturbance in intracapsular fracture of the neck of the femur, occurring in old people, is often of a very serious nature, and leads to a fatal issue. Hypostatic pneumonia or sloughing of the nates from pressure, during treatment, also frequently supervenes and causes the death of the patient. Hence this injury must always be regarded as a dangerous one, and the prognosis given of a very guarded nature.

Mode of union of intracapsular fracture.—These fractures, as a rule, unite by fibrous tissue, though true bony union may occur, probably in those cases chiefly where the fracture has been impacted. Sometimes no union at all takes place; the surfaces of bone then become eburnated and smooth, and the capsular ligament much thickened, so that the patient, by its means, is able to bear the weight of the body on the limb (Fig. 41).

Treatment.—The treatment of intracapsular fracture of the neck of the thigh bone depends mainly upon the age and constitutional condition of the patient. If he is not very aged and apparently of sound constitution, an effort should be made to bring the fragments into as accurate a position as possible,

and keep them there by extension. This is best done by the long thigh splint, with extension by means of the perineal band, or by a weight attached to the foot, and suspended by means of a pulley over the end of the bed. This treatment, if the patient is able to bear it, should be continued for about a month to six weeks, when the limb may be encased in a starched, pasteboard, or Hide's felt splint, and the patient allowed to move about on crutches. In those cases where the fracture is impacted no attempt should be made to disengage the fragment; for not only would it require a degree of violence which is quite unjustifiable, but the



The two surfaces of the fractured neck are quite smooth and polished. The two fragments in the shaft overlap each other for about six inches, and are firmly united by bony callus. The preparation was taken from the body of a man who had completed his ninety-ninth year, and in whom, on account of pain and the formation of sores from pressure, it was impossible to apply any extension. He had fractured the neck of his femur some years previously, but had always been able to get about until he sustained the second fracture. (From a preparation in the museum of St. George's Hospital, series i., prep 167, *a*.)

Fig. 41.—Ununited Fracture of the Neck of the Femur and Faulty Union of the Shaft.

impaction places it in the most favourable condition for bony union. These cases only require rest. The limb should have a long splint applied, not for purposes of extension, but merely to steady it and keep it quiet, and as soon as all pain and swelling, if any has existed, have subsided, the part may be put up in some form of fixed apparatus, and the patient allowed to get about on crutches.

Should the patient be very old and feeble, the lengthened confinement in bed required by this plan of treatment would probably prove fatal from the supervention of bed sores or the occurrence of visceral congestion, and must not therefore be adopted. The best plan in these cases is to confine the patient to bed for two or three weeks, with the limb supported by means of sand-bags, and if he is able to bear it, extension may be made by a weight attached to the foot; or the treatment recommended by Sir Astley Cooper may be adopted. This consists in merely supporting the knee on a pillow until the limb has become less painful. At the end of this time the hip is to be encased in an immovable splint of leather, pasteboard, or felt; or a Thomas's splint may be applied, and the patient allowed to get about on crutches. The result of this may be, that the patient will be more or less lame for the remainder of life; but this is better than subjecting the patient to the risk of those complications from which his life might probably be endangered or sacrificed.

If in the course of treatment the case should become complicated by the formation of bed sores, or, what sometimes happens, sloughing from the pressure of the splints, then all active treatment must be stopped. The limb must be left to take care of itself, the patient being allowed to get up daily and sit in a chair, or, if he is able, to move about on crutches, with the injured leg supported in a sling.

β. **Fracture at the junction of the neck with the greater trochanter.**—These fractures are often described as "extracapsular" fractures, but this is, strictly speaking, not absolutely correct, as the fracture usually takes place partly within and partly without the capsule.

The fracture generally follows the line of attachment of the capsular ligament in front, passing down the anterior intertrochanteric line. Behind, it lies external to the capsule, passing just internal to the posterior intertrochanteric line. The course of the fracture varies, however, very considerably, for it is almost always comminuted. The greater trochanter is frequently splintered into several fragments, or the lesser trochanter detached, or the line of fracture behind runs below the lesser trochanter, and involves the upper part of the shaft of the bone (Fig. 42).

Fig. 42.—Extracapsular Fracture of the Neck of the Thigh Bone.

The head and neck are separated from the upper part of the shaft by a fracture, which follows the course of the intertrochanteric line in front and behind, separates the greater and lesser trochanters into several fragments. The neck is impacted among these fragments. (From a preparation in the museum of St. George's Hospital, series i., p. 142.)

Dr. Ogston states that in this fracture the bone is usually divided into three fragments, the first formed by the head and neck, the second by the greater part of the trochanter major, and the third by the shaft of

the bone and a small portion of the trochanter minor; and in an interesting article explains this by the application to the subject of mechanical laws.*

These fractures are very frequently impacted. In fact, Dr. R. W. Smith expresses his belief "that all extracapsular fractures are, in the first instance, also impacted fractures." At all events, it seems probable that in most instances the neck of the bone is driven into the trochanter, where it may remain fixed, or the trochanter may be split up, and thus no fixation take place.

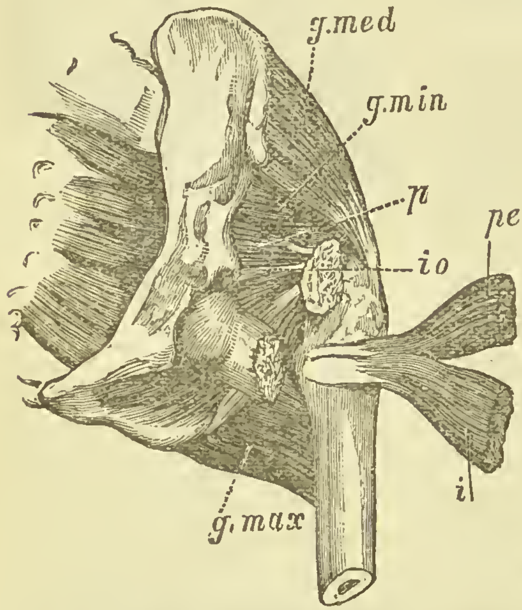


Fig. 43.—Fracture of the Neck of the Femur.

The diagram shows the displacement which results from muscular action in fracture of the neck of the femur; *g. med*, gluteus medius; *g. min*, gluteus minimus; *p*, pyriformis; *io*, obturator internus; *pe*, psoas magnus; *i*, iliacus; *g. max*, gluteus maximus. (After Hind.)

Where no impaction occurs there is always more displacement than in the intracapsular variety. The line of fracture being for the most part external to the capsular ligament, there is nothing to oppose the force of the muscular action upon the lower fragment, which is drawn upwards by the glutei muscles and the combined action of the rectus femoris in front, and the biceps, semitendinous, and semimembranous behind; and is, at the same time, everted from the same causes

* See *Medical Times and Gazette*, vol. i., p. 516; 1869.

which produced eversion in the intracapsular fracture (Fig. 43).

Causes.—Extracapsular fracture is produced by the application of great and direct violence on the trochanter major, as from a fall laterally upon the hip. When a patient falls in this way the weight of the pelvis acts obliquely on the under surface of the neck, which receives the force in a most unfavourable manner, and first cracks across; the impulse being continued, the fracture extends and becomes complete. If the force is prolonged it is easy to understand how the neck of the bone is driven into the loose cancellous tissue of the trochanter, and remains impacted there, or splits it up in various directions, producing the comminuted fractures of this process, which are so commonly met with in this form of injury.

Symptoms.—When the extracapsular fracture is not impacted, the signs by which it may be recognised are well marked, and there can be no probability of mistaking it for the intracapsular variety; for though to a certain extent the signs of the two injuries are the same, still in the extracapsular form of injury they are much more strongly marked than in the other variety. The violence by which the fracture is produced is very much more severe, and is usually applied transversely.

The crepitus is generally well marked, and the shortening very great; while the pain and constitutional disturbance are much more severe than in the intracapsular fracture.

In diagnosing the injury there is the history of a severe blow or fall upon the hip. The patient is found to be more or less collapsed, and to complain of great pain in the part, which is found to be swollen and ecchymosed, and present signs of a direct injury. Any attempt to move the limb is attended with very

severe pain, and the patient is unable to move it in the slightest degree by his own unaided efforts.

The limb is considerably shortened, and generally everted, the shortening never being less than an inch and a half; frequently as much as two inches and a half or three inches. The eversion is very complete, the whole limb being rolled outwards, and resting on its outer side on the bed, with the thigh flexed somewhat on the pelvis, and the leg on the thigh.

The crepitus is very loud and distinct, and may be readily felt by laying the hand on the trochanter and rotating the limb.

When the fracture is *impacted*, the signs by which it may be recognised are not so clear, and are to a certain extent of a negative character. There is also more difficulty in diagnosing it, from the intracapsular form of fracture.

We have in these cases, however, as in the non-impacted form, the history of severe violence applied transversely to the hip, together with bruising and the local signs of injury, and severe fixed pain, increased by pressure on the trochanter or any attempt to move the limb. As a rule, the loss of power in the limb is also complete, though in exceptional cases the patient may be able to rotate it somewhat, or partially flex it. The limb is fixed and generally everted, though sometimes the foot is in a straight position, or even inverted, depending upon the position of the fragments at the moment of impaction. There is shortening generally to the extent of about an inch, and this no extension will rectify.

Crepitus is entirely absent, or only very indistinct, and no prolonged efforts should be made to elicit this sign, since it is quite unnecessary to establish the diagnosis, and the attempt to obtain it may be the means of doing irreparable mischief.

The trochanter will be found to be somewhat

displaced, being approximated to the median line of the body, and to the crest of the ilium,* but will be found to move with the head of the bone, when it is rotated in the acetabulum.

The diagnosis between the intracapsular fracture and the impacted extracapsular fracture is to be made by attention to the age of the patient, and by the degree and direction of the violence which caused the injury, and from the fact that in the latter form of injury extension will not restore the limb to its proper length, as in the former instance.

Treatment.—Extracapsular fractures unite by bone as soundly as fractures in any other situation. The endeavour of the surgeon should be, therefore, to obtain this result by overcoming the shortening, and bringing the broken ends into apposition by steady extension, and maintaining them there by a suitable appliance. If the patient is a sound and vigorous adult, undoubtedly the best means of maintaining the extension is by means of the long splint (Desault's or Liston's) and the perineal band; or, instead of the perineal band, some surgeons prefer to make extension by the application of a weight to the foot.

I have found considerable advantage in some cases by a combination of the two.

Sir Astley Cooper in these cases recommended the double inclined bed, with the feet and ankles tied together, and a broad well-padded belt strapped around the pelvis, so as to press the fragments of the trochanter firmly together.

This plan, however, is not so efficient, as far as extension is concerned, as the long splint, and is more likely to be followed by permanent shortening, though the patient is less exposed to the risk of ulceration or sloughing of the skin.

* For the means by which the position of the trochanter may be demonstrated, *see* page 237.

γ. **Fractures of the great trochanter.**—Fractures of the great trochanter may be of two kinds:

(1) Where the fracture passes through the great trochanter in such a manner that the head, neck, and part of the great trochanter are separated from the shaft and rest of the trochanter.

(2) Where this process itself is separated from the remainder of the bone.

(1) This form of fracture was described by Sir Astley Cooper as "oblique fracture through the trochanter major, without implicating the neck of the bone."

It is, in fact, as regards its direction, a very similar injury to the extracapsular fracture just described, the difference consisting in the line of fracture which starts from the lower portion of the neck, passing obliquely upwards and outwards, through the base of the trochanter major. Thus the head, neck, and upper and inner part of the great trochanter are separated from the lower and outer part, which remains connected with the shaft of the bone (Fig. 39).

The displacement which occurs in these cases is principally due to the lower fragment being drawn upwards and backwards by the glutæus maximus muscle, so that its upper end forms a prominence on the back of the ilium, in the neighbourhood of the sciatic notch, and simulates a dislocation.

The symptoms to a considerable extent resemble those of extracapsular fracture; that is to say, there is shortening, sometimes very considerable; great eversion of the limb, pain, increased by movement, and in some cases the patient is unable to turn in bed or to sit, any attempt to do so causing him great pain

There is also a very marked alteration in the position of the great trochanter, and distinct crepitus can

be felt by making extension, and then rotating the limb, or moving the trochanter with the fingers.

According to Sir Astley Cooper, the diagnosis from extracapsular fracture may be made by the fact that "the upper portion of the trochanter does not obey the motions of the lower, and of the shaft of the bone."

The treatment in these cases is the same as that which has been recommended for fracture of the neck of the femur ; namely, extension by means of the long splint, and steady support of the limb in its normal position.

II. **Fracture of the great trochanter,** without any fracture of the neck or shaft of the bone, has been said to occur.

Most of the recorded cases have, however, taken place in young persons, and were doubtless instances of separation of the epiphysis of the trochanter major.

The symptoms of this fracture, if it ever occurs, are identical with those of separation of the epiphysis, and the two injuries will therefore be considered together in the next section.

δ. **Separation of the epiphysis of the head of the femur** is no doubt a possible injury, and frequently, as is well known, occurs as a consequence of disease. As the result of injury I am not aware of any preparation which demonstrates the fact, and in consequence of the small size of the epiphysis, and its protected position within the acetabular cavity, its separation must necessarily be of rare occurrence.

Several supposed instances of this accident have been recorded. The two usually quoted are those by South, occurring in a boy of ten,* and by Post, in a girl aged sixteen ; † but in neither did the injury prove fatal.

The symptoms resemble those of fracture of the

* Chelius's "Surgery," p. 258.

† *New York Journal*, vol. iii., p. 190.

neck of the thigh bone, with the exception that the crepitus, if any exists, is of a soft character, differing from the harsh crepitus which is felt in a case of fracture of a young and healthy bone.

Separation of the epiphysis of the great trochanter is a more definite injury, which has been verified by post-mortem examination.* It appears always to be the result of direct violence. In this injury, and also where the trochanter is separated, later in life, from fracture, the broken fragment is usually drawn upwards and backwards by the action of the gluteus medius and minimus muscles and the small external rotators. In Mr. Aston Key's case, recorded by Sir Astley Cooper, the broken fragment was not displaced, being held in position by means of its fibrous and tendinous coverings. The symptoms are separation of the fragments, the trochanter being felt above and behind its natural position. Sometimes, on account of the swelling and extravasation of blood, this process cannot be made out. The movements of the hip joint can be made, and there is no shortening. When fracture has taken place, crepitus can be felt by flexing and abducting the thigh and rotating it outwards, at the same time that the fragments are firmly pressed together; and even in cases of disjunction of the epiphysis, a soft crepitus may be obtained by the same means.

In the treatment of these cases there is always the greatest difficulty in maintaining the fragment in its proper place. Sir Astley Cooper, in one case in which he believed that this injury had occurred, endeavoured, by applying compresses and bandages upon the upper portion of the trochanter, to draw it downwards and fix it in its place, and probably this

* Mr. Henry Morris has collected six examples of this injury, which appears to be all the well-authenticated cases which have been recorded.

is all that can be done. The prognosis, therefore, as regards the complete recovery of the movements of the hip, is most unfavourable, and the patient will probably recover with a certain degree of lameness.

Fractures of the shaft of the femur.—The shaft of the femur may be broken at any part, from just below the lesser trochanter to just above the condyles. The middle third of the bone is, however, much more frequently broken than either the upper or lower third, and the centre of the bone is the spot where fracture most commonly occurs. Fractures in the lower third are more common than those in the upper third, on account of the bone in the former situation being more exposed to the effects of direct violence. Fracture of the shaft of the femur may occur at any age, being proportionately more common in children than adults.

Causes.—Fracture of the shaft of the thigh bone may be caused by any of the influences which produce fracture; that is to say, either by direct violence, indirect violence, and muscular action.

Fractures in the upper third of the bone are almost always produced by indirect force, while in the lower third the fracture is caused for the most part by a direct blow; in the middle third either form of violence may produce the solution of continuity and in about equal proportions. The femur has often been broken by muscular violence, though not so frequently as the humerus. Nevertheless, a sufficient number of cases have been recorded to prove that this injury may take place without any apparent disease in the bone.

Fractures of the thigh bone may present every variety; they may be multiple, comminuted, and compound. They may be impacted* or dentated with the fragments interlocked.

As regards the direction, they may be oblique,

* *See* a case by Bryant; Path. Soc. Trans., vol. xxix., p. 190.

longitudinal, transverse, or spiral. The oblique fracture is probably the most common form in the adult, and in consequence of its being, for the most part, the result of indirect force, is more commonly found in the upper than the lower part of the bone. The most common direction which the oblique fracture of the femur takes, is, in the upper part of the bone, downwards and inwards, and in the lower part of the bone downwards and forwards, with usually a slight inclination either inwards or outwards. The oblique fracture of the lower end of the bone, where the direction is downwards and backwards, is not common, but is of especial interest, since in these cases the upper fragment is displaced backwards and its lower end is liable to injure the popliteal vessels or nerves, and produce a very serious complication.

The transverse fracture is especially likely to occur in children, in whom this form of fracture is more common than the oblique. In these cases the periosteum is thick, and not always completely torn across, and there is, therefore, very often little or no displacement.

Cases of longitudinal fracture, especially of the lower end, are not uncommon in the femur.

Mr. H. Morris has described, partly after M. Févé, a peculiar form of spiral fracture of the femur, produced by torsion, and which he terms, after M. Leriche, "helicoidal" fractures. M. Févé believes that the direction the line of fracture will take depends upon the manner in which the torsion is applied, whether inwards or outwards. He concludes that in "fractures caused by outward torsion the inferior fragment mounts upwards over the lower end of the superior fragment; and that in fractures caused by inward torsion it mounts upwards on the inner side of the superior fragment."*

* "System of Surgery," vol. i., p. 1021. 3rd ed.

As a rule, the *displacement* in fracture of the shaft of the femur is very considerable, and except in cases where impaction has taken place, or in children where the periosteum remains intact, it is rare for fracture to take place without some amount of displacement. Its direction depends to some extent upon the direction of the line of fracture. The lower fragment is drawn upwards, generally behind the upper fragment, and displaced a little to the inner side; especially if the fracture has taken place in the upper part of the shaft. The lower fragment is at the same time rotated outwards. The manner in which this displacement takes place appears to be as follows: When the femur is snapped across, the lower fragment naturally falls backwards, from the weight of the lower part of the limb. It is then pulled upwards by the rectus in front, and the hamstring muscles behind, and, at the same time, a little inwards, by the adductor muscles. Occasionally the lower fragment may be in front.

From the weight of the lower part of the limb the foot naturally falls outwards, all support to it having been withdrawn, and this, in consequence, produces the outward rotation of the lower fragment.

As a rule, when the fracture occurs in the upper third of the bone, the upper fragment is thrown upwards and outwards. This has been attributed to the combined action of the psoas and iliacus drawing the fragment forwards, while it is at the same time everted and drawn outwards by the external rotators and glutei muscles. But this displacement is not constant; sometimes it is found to have taken place in other directions, which would not be the case if the displacement were due solely to muscular action.

By most surgeons the alteration in position of the upper fragment is believed to be due, in a great

measure, to the pressure of the lower fragment against it, which drives it upwards and so produces more or less angular distortion.

Symptoms.—The signs of fracture of the shaft of the thigh bone are, in the majority of cases, so well marked and so palpable that a glance at the position of the limb is often all that is necessary for the surgeon to arrive at a correct diagnosis. The patient lies on his back with the injured thigh slightly flexed on the pelvis and the leg on the thigh. The whole limb is everted and rests on its outer side on the bed, and has a peculiar helpless appearance, the patient being unable to move it. The thigh appears also to be shortened and unnaturally curved.

When a more careful examination is made there is found to be actual shortening, sometimes to the extent of two or three inches; there is increased mobility in the continuity of the bone, and any attempt to move the limb is attended by great pain. The displaced fragments may often be felt prominently under the skin, especially the lower end of the upper fragment at the front and outer side of the limb. Crepitus can generally be felt, if the fracture is oblique, by simple rotation; if it is transverse, by rotation after extension has been made.

In some exceptional cases, where impaction has taken place, the diagnosis is not, perhaps, quite so easy; but by careful measurement the presence of shortening may be ascertained, and this, together with the alteration in the axis of the limb, which will be present, will establish the diagnosis.

Prognosis.—Since the days of Hippocrates much difference of opinion has prevailed as to whether a certain amount of shortening is or is not a necessary consequence of fracture of the shaft of the femur when displacement has taken place. Now-a-days surgeons are pretty unanimously agreed that it is impossible, in

the majority of cases, to prevent a slight degree of shortening, perhaps not more than half an inch. This shortening however, need not be so great as to be perceptible to the patient, or to cause him to limp in walking, for by a slight involuntary inclination of the pelvis it may be corrected, so that no alteration in the patient's gait can be perceived. Velpeau says that after fracture of the femur there is no limping unless the shortening exceeds three-quarters of an inch.

The shortening may be due to two different causes, either to the impossibility of restoring to its full length a thigh bone, shortened by fracture, by any force which can be safely applied to living tissue, or to the impossibility of maintaining a sufficient amount of extension after reduction has been accomplished. In regard to the first cause, Dr. Montgomery instituted an interesting experiment. In a case of fracture of the femur in a muscular man he tried reduction after death. The fracture overlapped to the extent of one inch and a quarter, and he found that extension by means of a weight of one hundred and twenty pounds over a pulley for seventeen hours was not sufficient to entirely overcome the shortening. He concludes, therefore, "that in most, and probably in all, cases of fracture of the femur, whether transverse or oblique, with shortening, the fractured ends of the bone cannot be placed in exact apposition by any force which can be safely applied to living tissue." *

In young children the probability of permanent shortening after fracture of the femur is not so great. In a large number of these cases the fracture is transverse, and in consequence of the periosteum being thicker it is often only partially, or even not at all, torn, and therefore the fragments have never quitted each other, but remain in contact. When, however, the fracture is oblique and overlapping has taken

* *Amer. Journ. Med. Sciences*, July 1872; p. 112.

place, there is often as great difficulty in young children as in adults in preventing shortening, on account of the impossibility of maintaining the requisite amount of extension from the delicacy of the skin and the liability to the production of ulceration from the pressure of the various appliances used.

As regards the ultimate recovery of the patient, a simple uncomplicated case nearly always does well. When occurring in old people, or if the fracture is compound or complicated with the wound of a large vessel or extends into the knee joint, the prognosis is unfavourable.

The *treatment* of fractures of the shaft of the femur may be conducted in different ways; that which is usually adopted in the London hospitals is by the long splint, the old-fashioned plan of treating fracture of the thigh in the flexed position having almost died out. Of the two forms of long splint, Desault's or Liston's, I decidedly give the preference to the former, on account of the support which it gives to the outer side of the foot, and which serves to obviate the tendency to rotation outwards. By most surgeons the two forms of splint are used indiscriminately, and no doubt excellent results may be obtained with either if properly applied.*

I am also a strong advocate for the application of three short thigh splints in addition to the outside long splint; they serve to remedy any angular displacement which may have taken place, and at the same time support the thigh and lessen the tendency to muscular spasm. Many surgeons, however, dispense

* If Liston's splint is used, a small wooden cross bar should be fastened below the splint and a few inches from its lower end. This will prevent the tendency to rolling outwards of the limb, and also form a mean by which the heel is raised from the bed, and obviates injurious pressure on this part. Or a sand bag may be laid along the outer side of the limb, which materially assists in keeping it quiet and preventing outward rotation.

with the use of short splints, and some, instead of them, bandage the whole limb evenly and carefully from below upwards.

In the treatment of fracture of the shaft of the femur by means of the long splint, extension is generally maintained by means of the perineal band, which is certainly a convenient and efficient means of attaining this object. It may be made of a piece of soft bandage, stitched so as to form a tubular bag, which is to be stuffed with cotton wool; or, what is better, of a leather strap, softly padded and covered with wash-leather. Occasionally it may happen that the perineal band will cause excoriation or undue pressure, when other means of extension must be resorted to.

A very ingenious contrivance for making extension has been invented by Mr. Buckstone Brown. It consists of a strong vulcanite ring attached to the foot by means of a stirrup in the ordinary way. The ring is connected, by a hook, to a screw stem attached to the lower part of the long splint, which should project about eight inches beyond the foot. Mr. Brown recommends that between the screw stem and the long splint a piece of inch plank should be inserted. This is firmly screwed to the splint, and the screw stem to it, by which means the direction of the traction is in a line with the axis of the limb. By turning the screw the amount of extension can be regulated to a nicety.*

Mr. Cripps' method of applying extension is by means of a jointed splint, with an indiarubber band or accumulator inserted into it, so that extension and counter-extension are kept up by one force, and can be carefully regulated.

Mr. De Morgan applies extension by means of a stirrup attached to the injured leg or foot, and which is connected by a series of pulleys, through a pedal

* *Lancet*, vol. ii., p. 511; 1874.

cross bar attached to a long splint applied to the sound side, with an indiarubber accumulator connected with the perineal band.

Mr. Bryant endeavours to do away altogether with the perineal band by means of a double long splint, one splint being applied to either side of the body, and the two connected together by sliding rods below the feet and over the chest; persistent elastic extension is kept up by means of an accumulator. The advantages that he claims for it are: (1) that it is far more comfortable than other splints; (2) that it most thoroughly immobilises the limb; (3) that it maintains parallelism of the lower extremities.

In the various plans which have been enumerated, the long splint has formed an essential element in the treatment of the case. Many surgeons, however, and especially American surgeons, are fond of discarding the use of the long splint altogether, and of applying four short splints between the groin and the knee, and making extension by means of a weight passing over a pulley attached to the bottom of the bed, counter-extension being made by a perineal band attached to the head of the bed. James, of Exeter, and, more recently, Gurdon Busk, of New York, have employed this means.*

Dr. Gurdon Busk uses a perineal band composed of indiarubber tubing stuffed with bran or cotton lampwick, and an extending weight of five to twenty pounds. He believes that better results may be obtained by this plan of treatment than any other. Professor Spence also strongly advocates the extension plan for treating fractures of the femur, and states that he now rarely uses the long splint; and, after some years' experience, "unhesitatingly commends the method to all who may not have tried it." †

* Hildanus appears to have been the first to treat fractured thigh in this way, and has described an apparatus for the purpose (Hildani, "Opera," p. 47).

† *Medical Times and Gazette*, vol. ii. p. 235; 1875.

A combination of the two plans has been advocated by some. That is to say, a long splint applied to the outer side of the limb, and extension by means of a weight and pulley attached to the end of the bed. The long splint can, if desired, have a hinge at the hip, so that the body can be flexed while the splint steadies the bone.

A second plan of treating fractures of the shaft of the femur is by means of suspension of the limb, the extension being maintained by the weight of the body. This plan of treatment has been mainly advocated by the American surgeons, and there are two different forms of apparatus by which it may be applied.

Dr. Nathan R. Smith's "anterior" splint consists of a framework of stout wire covered with cloth. This is bent in such a manner that when applied to the front of the limb the thigh is flexed on the pelvis, and the leg on the thigh. After the fracture has been set, the splint is securely bandaged to the limb, and then suspended, by two hooks inserted into it, to a pulley over the bed. The upper hook ought to be attached to the splint over the seat of fracture, the lower one about the middle of the leg.

Dr. Hodgen's suspension splint consists of a wire framework supporting a cotton sacking on which the limb is laid, and appears to be more generally preferred to Smith's anterior splint.

Mr. Cooper Forster speaks highly of this plan of treatment. He says it is the one which gives most comfort, and fulfils the two requirements of (1) keeping the muscles of the thigh in a state of relaxation, and (2) carrying out the principle of rest by traction upon the muscles.*

With these two exceptions, the treatment of fracture of the shaft of the femur in the straight position is now almost universally adopted by surgeons.

* Guy's Hospital Report, 1876; p. 117.

But, formerly, fractures of the upper and lower third were treated in the flexed position. This treatment was first advocated by Pott, who recommended that the leg should be flexed on the thigh, and the thigh on the trunk, and the limb laid on its outer side on the bed. And this treatment is still advised in certain cases by some surgeons in the present day. Mr. Erichsen adopts it in the treatment of fracture about a couple of inches below the trochanter, and has found these cases turn out better in this way than by any other plan of treatment.

Many surgeons adopt the plan of putting up the fractured thigh at once in some immovable apparatus as plaster of Paris, pasteboard, or leather. Except with children, I have had no personal experience in this plan of treatment, for it has seemed to me that the difficulties of maintaining a sufficient amount of extension during the process of setting or drying is a great objection to its use. And, at the same time, I have feared that from the shrinking of the limb, the bandages might become loosened, and some deformity result, which would remain unrectified on account of the impossibility of seeing and examining the fracture. The plan of treatment has been, however, strongly advocated by Erichsen and Gamgee in this country, and by many surgeons in America, and very good results have been said to have been obtained by its adoption.

I have constantly, however, used the plaster of Paris splint in young children and infants, in whom the long splint is not very applicable on account of the bandages becoming constantly soiled with urine and fæces, and constantly requiring renewal. In them the necessary amount of extension may be kept up, without fatigue, by the hands of a dresser or nurse during the process of setting, and as in these cases there is less tendency to displacement, the fracture,

* "Science and Art of Surgery," vol. i., p. 436.

as a rule, does well. The plan also possesses this further advantage, that the child need not be confined rigidly to bed, but can be nursed or carried about.

I have treated many cases of fractured thigh in children with a very simple apparatus. This is merely the ornamental covering which is made and sold in shops for flower-pots (Fig. 44). The limb is first surrounded with a flannel bandage or enveloped in cotton wool, after the fracture has been set. The apparatus is then slipped over the thigh, and secured with a couple of straps and buckles. It is well to cut it down somewhat (as shown in the figure) so that it may extend higher on the outer than the inner side of the thigh. If it should be considered necessary, extension can be made in addition from the foot by means of a pulley attached to the end of the bed; the child's shoulders being fixed to the head of the bed to prevent it slipping.

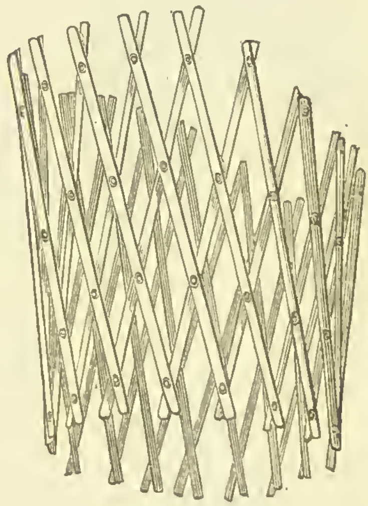


Fig. 44.—Splint for Fractured Thigh in Children.

This consists in the ornamental covering which is usually sold in shops for flower pots. It has been cut away on one side, so as to allow of its extending higher on the outer than the inner side of the thigh.

In an adult a fracture of the femur generally appears to be fairly firm in about ten weeks; it is advisable, nevertheless, to continue the treatment, and not allow the patient to go about without any support for at least twelve weeks. The fracture may appear to be firmly consolidated; but will, nevertheless, gradually yield under the weight of the patient's body, especially if it is an oblique fracture, and an

irremediable deformity result. For about half the time (six weeks or so) the patient should be confined to bed, and constant extension kept up. At the end of this time the limb may be put up in some form of immovable apparatus, and the patient allowed to move about on crutches, with his foot suspended by a sling round the neck.

3. **Fractures of the lower end of the femur.**—The fractures which are met with in the lower end of the femur are the same as those described as occurring in the lower end of the humerus, and may be classified in the same manner; viz. (1) Fracture of the shaft above the condyles; (2) transverse fracture above the condyles, with a vertical one between these processes, the T-shaped fracture; (3) oblique fracture, separating either the outer or the inner condyle; (4) longitudinal incomplete fracture between the condyles; (5) separation of the lower epiphysis.

(1) **Fracture of the shaft above the condyles.**—This fracture generally takes place about two inches above the epiphysial line, and corresponds to the place where the compact tissue of the shaft somewhat suddenly merges into the loose cancellous tissue of the lower end of the bone. This is just the situation where the femoral artery lies close to the bone, crossing it to reach the ham. This vessel is therefore in danger of being wounded by fractures in this situation.

The fracture is generally transverse, or nearly so, in a lateral direction, but is oblique in an antero-posterior direction, the bone being broken from above and behind downwards and forwards. In some instances the bone is fractured obliquely in a lateral direction from without downwards and inwards. Occasionally the fracture may be impacted, or the fragments dentated, when little displacement takes place.

In the ordinary fracture the displacement is very great, and is difficult to overcome. For, in addition to the fact that the lower fragment is drawn upwards by the rectus in front and the hamstring muscles behind, it is also powerfully acted upon by the gastrocnemius, popliteus, and plantaris muscles, which flex it upon the tibia, so that although the limb may be apparently extended, the knee joint is really flexed, and any attempt at extension by pulling on the gastrocnemius tends to increase the deformity by dragging the fragment farther into the ham (Fig. 45). The lower end of the upper fragment is also displaced, being drawn inwards by the adductor muscles.

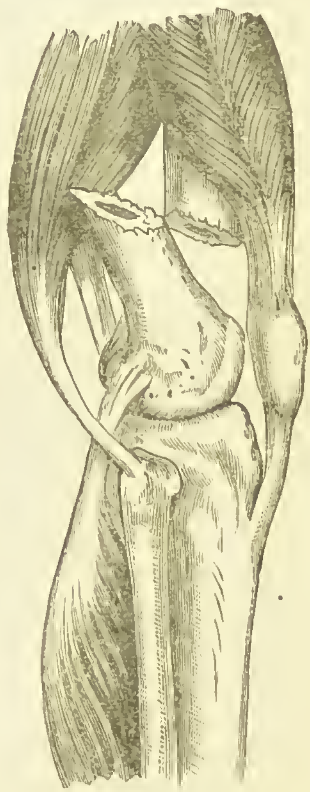


Fig. 45.—Fracture of the Lower part of the Femur.

The figure shows the displacement which takes place from muscular action in fracture of the lower part of the shaft of the femur. (After Hind.)

Causes.—The fracture is usually produced by direct violence, but may also be caused by indirect force, as a fall from a height upon the feet. Hamilton states that they may be produced by a direct blow on the patella with the knee bent.

Symptoms.—The diagnosis is generally perfectly easy. It presents all the characteristic signs usually met with in fracture. There is considerable shortening, and great deformity of the limb. The lower end of the upper fragment can be felt prominently under the skin, sometimes having pierced the rectus muscles, and occasionally the skin; while the lower fragment can

be felt deep in the popliteal space. There is increased mobility above the knee joint, and crepitus may be felt, probably from the rubbing of the lower end of the upper fragment against the anterior surface of the lower one, on which it rests. In some cases the knee joint has been wounded from the upper fragment penetrating the cul-de-sac of synovial membrane beneath the quadriceps extensor muscle, when the nature of the displacement may be masked by the effusion which takes place into the joint.

The T-shaped fracture is merely a modification of the above, and is probably, at all events in some cases, caused by a continuance of the force, which produces the fracture above mentioned, driving the shaft of the bone into the loose cancellous tissue of the condyles, and splitting them vertically from each other; or, in other cases, where the force is greater, breaking them up into a number of fragments.

In the T-shaped fracture the symptoms are much the same as in the fracture above the condyles, with the addition that the breadth of the lower end of the femur is very perceptibly increased, and crepitus can easily be elicited by moving the condyles on each other, or, in some cases, by rubbing the patella from side to side over the intercondylar notch.

Treatment.—In spite of the great amount of displacement, and the difficulty in overcoming it, the treatment of these fractures is generally fairly successful. I have always employed the double inclined plane, and have seen no cause to be dissatisfied with the results obtained by its use. By this means the hamstring muscles, and also the muscles of the calf, which drag the lower fragment backwards, are all relaxed, and, in addition to this, the angle of the splint, which may be supplemented by a pad placed upon it, serves to push the lower fragment into position. Some surgeons prefer the long splint and

extension. If this plan is adopted, the recommendation of Mr. Bryant, of dividing the tendo Achilles, should be carried out. This paralyses the gastrocnemius muscle, and extension can then be made without any fear of the lower fragment being drawn backwards into the ham. Treves states that in three cases he has performed this operation, and then treated the fracture in the extended position. The effect upon the position of the fragments was in each case very good.*

(3) **Oblique fracture, separating one or the other condyle.**—This injury is, for the most part, produced by direct violence, as by a kick from a horse, or by a fall upon the bent knee.

In these cases there is no shortening, since the remaining condyle prevents any displacement of the tibia on the femur taking place. But the fractured condyle is usually displaced upwards, and the leg deflected to the injured side. There is also increased breadth between the condyles, and crepitus is easily to be felt by seizing the broken fragment and moving it to and fro. There is always a greater or less amount of effusion into the knee joint, which, if considerable, may mask the other signs.

These fractures are to be treated in the straight position. If the deflected limb be drawn straight, the displaced fragment, still probably connected to the bones of the leg by the ligaments, will be drawn downwards into its normal position, and the limb being maintained in this position by a long splint, union will take place without much deformity.

Sometimes a small piece of one or other condyle may be broken off, and lie loose in the joint, giving rise to symptoms resembling "loose cartilage." Such a case is recorded as having occurred under the care of Prof. Volkmann, where the accident happened

* *Brit. Med. Journal*, vol. i., p. 307; 1883.

from a violent fall on the knee.* In a similar case, under Mr. Simon, the fracture was produced by a violent wrench.† In both instances the portion of bone was successfully removed.

(4) **Longitudinal fractures** of the lower end of the femur, in which fissures run upwards from the knee joint for a considerable distance, are not uncommon. They are generally caused by falls on the feet or knees. There is often little or no displacement, but sometimes the lower end of the femur can be felt to be increased in breadth. If the fracture has caused any displacement of the articular surface, the irregularity can generally be felt by moving the patella from side to side over the intercondyloid notch, when, instead of the smooth surface felt in the healthy joint, an unevenness and a rough grating will easily be perceived.

In all these fractures in the neighbourhood of the knee joint there is a probability of a certain amount of stiffness of the articulation remaining. Passive motion should therefore be commenced at the end of the fifth or sixth week, and steadily persevered with. Even if a certain amount of adhesion has taken place, it will often yield to treatment, and a useful limb result.

(5) **Separation of the lower epiphysis of the femur.**—This is not a very uncommon accident, occurring in young persons under the age of nineteen or twenty. In some of these cases there is an ordinary separation of the epiphysis, the fracture passing more or less entirely through the line of junction of the epiphysial cartilage; in others there is a mixture of fracture with disjunction of the epiphysis.

In these injuries the symptoms are much the same as those of transverse fracture of the lower end of the femur, and the possibility of this lesion having taken

* *Deutsche Klinik*, p. 448; 1867.
† Path. Soc. Trans., vol. xv., p. 206.

place must be borne in mind in dealing with injuries of this part in young persons.

The *treatment* consists in putting up the limb on a double inclined plane, in order to relax the muscles which act upon the fragments, and treating the case as an ordinary fracture. It must be borne in mind that in these cases there may be a suspension of growth of the bone, and it is well to warn the patient and his friends of the possibility of the occurrence of such an evil.

Compound fractures into the knee joint generally require amputation. But exceptions may be made in the case of healthy, vigorous adults and in children, unless there is much injury to the neighbouring parts. In these cases there is little doubt that the limb may often be saved.

Fracture of the Patella.

Fracture of the patella is a very common injury. It occurs in two main forms, which differ as to their cause, the direction of the fracture, and in other particulars, and require separate consideration. The one is produced by muscular action and is transverse in direction; the other by direct violence, and is stellate, oblique, or vertical.

Transverse fracture of the patella.—This is the more common form of fracture, and is produced by muscular action, the patella being more often broken by this means than any other bone in the body. The manner in which the fracture is produced is peculiar, and not simply the result of the muscular contraction tearing the bone asunder, for the lesion could never be caused by the muscles simply pulling off the upper fragment. It occurs when the knee is in a position of semiflexion. At this time the middle third of the articular surface of the patella is in contact with the condyles, the

upper portion of the bone projecting above them. Under these circumstances a violent contraction of the quadriceps extensor, which acts in a line nearly at right angles to the vertical axis of the patella, may snap the bone in two, much in the same way as a piece of stick may be broken across the knee.

In transverse fracture of the patella from muscular violence the fracture is always, I believe, complete, and the fibrous structures which cover it in front and the cartilage and synovial membrane on its articular surface are also torn. In these cases, therefore, the joint is always opened. It is true that, as Mr. Henry Morris has pointed out, it is "anatomically possible, if the fracture involve only the lower and non-articular portion of the patella, and if the amount of separation of the fragment is slight, that the fatty tissue behind the apex of the patella over which the synovial membrane is reflected may save the latter from injury." But in these cases the fracture generally occurs near the centre of the bone, and therefore the synovial membrane in all transverse fractures of the patella, produced by muscular violence, is lacerated. The aponeurotic covering of the bone is also torn, and in many cases the patella bursa opened up. It is true that there are one or two cases on record of transverse fracture of the patella, where the fracture is incomplete; that is to say, does not involve the whole thickness of the bone. But the probabilities are that these lesions were produced by direct violence and not by muscular action. Notably a specimen in the Musée Dupuytren,* where the fracture "involves only the articular surface, and extends but little deeper than the articular cartilage." There is unfortunately no history attached to the preparation, but it is clear that the

* Quoted in "System of Surgery," No. 208D in M. Houet's catalogue.

fracture, being on the articular surface, could not have been caused by muscular action, since the solution of continuity must take place in these cases from without inwards, and not commence on the internal or articular surface.

When the separation which takes place between the fragments is great, the fibrous expansion on either side of the bone must also be torn to a considerable extent. This may be proved experimentally. The patella may be divided transversely, in the dead subject, with a chisel, and very little separation of the fragment will take place, even though the knee is bent. If now the fibrous expansion on either side is divided with a knife, and the knee again flexed, very considerable separation at once occurs.

In consequence of this injury to the synovial membrane the joint becomes rapidly filled with fluid; at first with blood, and subsequently with synovial fluid the result of inflammatory changes in the synovial membrane, in consequence of the injury. The inflammation rarely, however, goes on to suppuration, unless indeed the fracture is compound. An accident which fortunately hardly ever occurs, nor indeed is it likely to do so, except in cases such as that recorded by Dr. Erskine Mason, where a second fracture took place, through the uniting medium, with laceration of the skin over it, no doubt on account of the two tissues being firmly united together as the result of the first fracture.

Occasionally both patellæ may be broken by muscular action at the same time. Mr. Johnston records a case of simultaneous fracture of both patellæ from muscular action.* And an instance of the same accident is recorded in the *Boston Journal*, where both patellæ were fractured at the same time by a mis-step

* *Lancet*, vol. ii., p. 661 · 1873.

off the curb stone and a violent muscular effort on the part of the patient to prevent himself falling.*

Symptoms.—The signs by which a transverse fracture may be recognised are generally well marked, and there is never, as a rule, much difficulty as regards the diagnosis. The history of the manner in which the accident occurred and the sudden loss of power in the limb are very characteristic. The loss of power in the quadriceps extensor is complete. If a patient with transverse fracture of the patella be requested to raise his limb from the bed he will be quite unable to do so. The separation of the fragments can easily be felt, and if no effusion has taken place a distinct depression can be seen, into which the finger can be buried. If, on the other hand, effusion has taken place there will be an accumulation of fluid between the fractured ends. The interval between the divided portions of bone is increased by bending the knee. For the most part the quadriceps extensor is quite flaccid, and if there is no effusion into the synovial sac, there is no difficulty in pushing down the upper fragment until it touches the lower, and in this way crepitus may be elicited. In the course of a short time after the accident synovitis of varying degrees of severity will supervene, attended by effusion, during which time approximation of the fragments is difficult or altogether impossible. This generally lasts from ten days to a fortnight. From this it follows that the main cause of the difficulty in the approximation of the fragment is not due to the continued contraction of the extensor muscles of the thigh, but to the effusion into the joint pressing the pieces of bone apart. Later on it may also be due to the contraction of the fibrous structures and to the swelling of the injured tissues in the neighbourhood.

* *Medical Times and Gazette*, vol. ii., p. 670; 1874.

Mode of union.—The union of ordinary transverse fracture of the patella, where there has been considerable separation of the fragments, is rarely effected by bone. Some difference of opinion exists among surgeons on this point. Mr. Hutchinson states "that no proof has yet been afforded that transverse fracture of the patella with considerable separation at the time ever unites by bone." * Mr. Morris, on the other hand, while admitting its rarity, believes that it sometimes occurs, and has collected four cases in which complete bony union has taken place, and one or two others where the union is partially bony. One of these cases is quite conclusive, as the history of the accident is definite, the patient having been treated three years previous to his death for transverse fracture with $2\frac{3}{8}$ inches separation, and after death it was proved that "firm osseous union had occurred." †

As a rule, in transverse fracture the union is fibrous. This may vary very much as regards its amount. The fragments may be so closely united by fibrous tissue that no movement between the fragments can be made and it is impossible to detect the line of union. In other cases the union may consist of ligamentous fibres of greater or less density, which may stretch almost indefinitely, so that the fragments may be separated to the extent of as much as five or six inches. Sometimes it happens that no union whatever takes place between the fractured surfaces, and the only means by which they are connected is the thickened fibrous capsule and other tissues external to the joint.

The fibrous bond of union when first formed is very pliable and extensible, but becomes firmer and more resisting after a time. From this it happens,

* Medico-Chir. Trans., vol. lii., p. 333.
† "System of Surgery," vol. i., p. 1030.

that patients who have apparently recovered with good and close union, if allowed to bend the knee, will return after the lapse of time with the union stretched and the fragments separated to a considerable extent.

Mr. Hutchinson has pointed out that one important result of transverse fracture of the patella is a remarkable wasting of the quadriceps extensor, which is "altogether out of proportion to that of the other muscles of the limb, and is almost invariably attended by loss of power." From this cause impaired stability often follows fracture of the patella, and it not unfrequently happens, from the unsteadiness of gait, that the opposite patella is broken from an effort to save a fall, or refracture of the same bone may occur. Under these circumstances a fresh fracture occurs in some other part of the bone; it is rare for the ligamentous union to give way. Bryant figures a case in which the bone had been broken in three places.

Treatment.—In the treatment of fracture of the patella, the great object is to bring down the upper fragment, so as to approximate it to the lower. and obtain union with as little separation as possible, We have seen that the principal cause of the separation of the fragments is due to the effusion which takes place into the joint, and not, as was formerly supposed, to the action of the quadriceps extensor muscle. The first indication, therefore, in these cases is to get rid of the effusion, and this may be done either by aspiration of the joint and withdrawal of the fluid, or by pressure by means of a Martin's bandage, or by the application of cold evaporating lotions or ice. Probably the first means is the most efficient, though not quite devoid of danger.* For if the other means

* *See* a case by Mr. Rivington, *Lancet*, Jan. 24, 1885; p. 154. In one case which occurred in St. George's Hospital, it was found impossible to withdraw more than half-an-ounce of fluid, because the aspirator became plugged with small clots; this, however, does not generally occur.

are adopted, before the effusion is absorbed, a certain amount of rigidity of the aponeurotic structures about the joint may have set in, and thus prevent the perfect adaptation of the fragments. After the effusion has been got rid of, there is generally no difficulty in approximating the two fractured surfaces, and they can be then retained in position by two pieces of strapping, placed the one above and the other below the patella, and crossed behind the joint. The limb is now to be put up immediately in some immovable apparatus, such as a starched bandage, the pressure of which generally prevents any further effusion taking place. This plan of treatment possesses the advantage of enabling the patient to get up and move about at the end of a few days, instead of confining him to bed for some weeks, and secures a most perfect apposition of the fragments.

Formerly it used always to be insisted that it was necessary to raise the limb on a single incline plane, in order to relax the quadriceps extensor muscle, and this plan is still adopted by many surgeons.

Many means have also been devised at various times for drawing down the upper fragment; of which, perhaps, Malgaigne's hooks have been the most extensively employed. They are not without several objections. When they are made to penetrate the soft parts, as originally advised by Malgaigne, they are apt to set up suppuration, which may even extend into the joint. In one case I have seen erysipelas follow their use. They have also a tendency to tilt the lower end of the upper fragment forwards, so that the whole of the broken surfaces are not in apposition.

The plan adopted at the Middlesex Hospital is to apply a piece of moleskin plaister, cut out at one side to fit the upper border of the patella, to the front of the thigh, and by means of an indiarubber band

attached to the lower angles of the anterior border of the moleskin and to the foot piece of the McIntyre's splint, in which the limb is placed, to make the requisite amount of extension.* Somewhat similar plans are advocated by Callender† and by Grant.‡

Mr. Teale, of Leeds, recommends what he calls the "expectant treatment in transverse fracture of the patella." He believes that the separation of the fragments depends entirely on the effusion into the joint, and that as this subsides the fragments will come together. His treatment, therefore, consists in simple rest of the limb between sand bags, without any attempt to bring the fragments into apposition.§ Mr. McGill also advocates the same plan of treatment.||

Whatever plan of treatment is adopted, it must be remembered that the fibrous union is at first soft, and will easily stretch if the patient is allowed to bend his knee, so that he should be enjoined to wear a knee cap with a stiffener behind, so as entirely to prevent flexion for at least twelve months. We have in these cases two alternatives to choose from: either keeping the knee straight, with the probable risk of permanent stiffening, or to allow the patient to move his knee, with the inevitable result of stretching the ligamentous union. Though it must be admitted that even with great separation of the fragments a fairly useful member may be secured, still it seems to me that a more useful and reliable limb will be obtained by a close approximation of the fragments, even though there is a certain amount of stiffness, and there will be at the same time less risk of refracture, or of fracture of the other patella, than in the former case.

* "System of Surgery," vol. i., p. 1033.

† Bartholomew's Hospital Report, 1874.

‡ *Edinburgh Medical Journal*, p. 317; 1876.

§ *Practitioner*, vol. xiv., p. 188; 1875.

|| Ibid., vol. i., p. 75.

One other method of treating fracture of the patella requires notice, since it has found many advocates in recent times. This consists in exposing the fragments and wiring them together. This plan of treatment has been advocated not only for fractures of old standing, where the degree of separation has been so great as permanently to cripple the patient, or in old ununited fractures where the limb is quite useless, but also in cases of recent fracture. And while all surgeons must admit that in the former class of cases the operation is not only justifiable, but also expedient, there are many who think, with Mr. Holmes, "that the natural results of the injury under ordinary treatment are not sufficiently disabling to justify a treatment fraught with such grave danger to limb and life." With this opinion I most cordially agree, and can only say that should I be so unfortunate as to break my own patella, I would not consent to have this operation performed on myself, and I do not, therefore, feel justified in recommending it to my patients.

2. **Vertical or star-shaped fracture of the patella the result of direct violence.**—These fractures differ in many essential particulars from the preceding. They are usually produced by falls on the knee, and may be star-shaped, V-shaped, oblique, longitudinal, or variously comminuted. They may be, and often are, incomplete; that is to say, they do not extend through the whole thickness of the bone; or, in other cases, the fractures on the two surfaces of the bone may not correspond. In may cases, also, the fibrous expansion of the ligamentum patellæ over the surface of the bone is untorn; so that, from these causes combined, no separation of the fragments is possible. The nature of the injury is, therefore, very liable to be overlooked. The signs which guide us in arriving at a diagnosis are the nature of the injury; a severe blow or fall on the knee, followed by

considerable bruising and ecchymosis, with possible effusion into the joint, inability to move about except with great difficulty and pain, and perhaps crepitus. This latter sign may be best felt by grasping the bone with the finger and thumb, and then pressing all over the bone and around the circumference with the finger of the other hand. There is no question that these fractures, even when penetration of the joint has taken place, may unite by bone. The treatment is sufficiently simple. All that requires to be done is to keep the limb quiet on a McIntyre's or an ordinary back splint, and apply cold lotions to allay inflammation. Should any displacement have taken place, the fragments are to be brought together by pads and maintained in position by a bandage or strapping. Passive motion in these cases should not be delayed too long, since the inflammation caused by the injury may result in permanent stiffness, and there is no reason why in these cases it should not be employed early.

Compound fracture of the patella is a very serious injury, and is always the result of direct violence. In a large proportion of cases it is accompanied by other injuries which necessitate amputation. If occurring alone, except in the very old and feeble, an attempt should be made to save the limb. Mr. Poland has collected eighty-five cases, in sixty-three of which the joint suppurated, and his records clearly show that in favourable cases a very useful limb may be obtained.

The treatment should be conducted on strictly antiseptic principles; all loose particles of bone and foreign bodies having been removed, every portion of the joint should be thoroughly syringed out with carbolic acid. The surgeon should not grudge the time necessary to completely cleanse the joint and wash away every particle of dirt and clot of blood. The edges

of the wound must then be accurately adapted, a horse-hair drainage tube having first been passed through the joint. The knee should be dressed with antiseptic dressing and securely fixed on a splint. If suppuration comes on free incisions will be necessary. And if there is failure of union and gradual decline of the patient's strength, secondary amputation will be required.

Fracture of the Bones of the Leg.

In fractures of the leg both bones are usually broken, although each bone may be broken separately. When this occurs, the fibula is oftener fractured alone than the tibia. The proportion in a hundred cases would be about fifty per cent. of both bones, about thirty-three of the fibula, and seventeen of the tibia alone.

Fracture of the bones of the leg is not common in children; in fact, as compared with fracture of the femur, they are very uncommon.

Fracture of the Tibia.

Fracture of the tibia may take place either at the upper end, through the shaft, or at the lower end.

Fractures of the upper end of the tibia may be transverse, oblique, or longitudinal, and to these must be added separation of the spine of the tibia; a remarkable accident, of which one case has been recorded by Dr. Hutton, and three others in the *Medical Times and Gazette* for 1876. The upper epiphysis of the tibia may also be separated.

Fractures of the upper end of the tibia are much more uncommon than fractures elsewhere, and are almost invariably the result of direct violence. In the transverse fracture there is, as a rule, little displacement; at all events, the bony surfaces are not completely disengaged from each other. It not

unfrequently happens that the transverse fracture is complicated with a vertical fracture running upwards between the tuberosities into the knee joint. In these cases, in addition to the ordinary symptoms of fracture, rapid effusion takes place into the joint; probably, in the first instance, of blood, afterwards of synovial fluid.

In the oblique fracture, one or other tuberosity may be broken off, the leg is then deflected to the opposite side.

Vertical fracture of the upper end of the tibia may occur with or without a transverse fracture. Of this there is an interesting specimen in the museum of St. George's Hospital, in which there are two separate lines of fracture.

A curious case of injury to the upper end of the tibia is reported by Dr. Hutton. The patient was wrestling, and was thrown violently to the ground, while in a state of intoxication. He died on the twenty-third day after the accident, of pleuro-pneumonia. After death it was found that the spine and central portion of the head of the bone, and a part of the left articular surface, had been torn from the rest of the bone.* In an annotation in the *Medical Times and Gazette*,† the writer refers to this subject, and states that in his opinion it is possibly more common than is generally supposed. He refers to a case under the care of Professor Dittel, of Vienna, where a man, struggling with another, was violently kicked, either in the calf or ham. This was followed by effusion of blood into the knee joint. Amputation followed puncture, and upon examination of the limb it was found that the anterior crucial ligament had become detached from its lower origin, tearing with it an oval piece of the upper surface of the tibia. The writer also refers to two other cases where a precisely similar

* Reported in the "System of Surgery," vol. i., p. 1038.
† *Medical Times and Gazette*, vol. ii., p. 389; 1876.

condition was discovered, one described by Poncet in the "Bulletin de la Société de Chirurgie," 1875, taken from a patient who had fallen down three storeys and fractured the base of his skull; the other a boy, aged eleven, who was admitted into University College, having been run over, and in whom there was such extensive destruction of the soft parts of the leg as to necessitate amputation. No special complaint of the knee was made, nor was there anything externally to point to any injury. This lesion would appear to belong to that class of fracture which has been described by the late Mr. Callender as "sprain fracture," to which allusion has been made above (*see* page 12); and, as the writer in the *Medical Times* suggests, it may be that in those cases of intractable inconvenience and trouble in the knee joint, which is referred to a strain, this injury may have taken place.

The signs by which fractures of the upper end of tibia are characterised are not always well marked. Being produced by direct violence, there is usually very considerable swelling and bruising about the part, sometimes so much so as to obscure the other signs; when the fracture has extended into the knee joint, the case is further obscured by effusion into the synovial sac; so that in some cases the fracture has been overlooked. This is the more likely to occur, inasmuch as in the transverse, and especially in the vertical fracture there is often little displacement. In the oblique fractures, however, or where the bone has been comminuted, the deflection of the limb, the increased mobility, and the crepitus, which is easily elicited, render the diagnosis at once easy and certain.

Fractures of the upper end of the tibia unite readily, and, as a rule, without deformity. The only inconvenience which is likely to follow is more or less stiffness of the knee joint, especially if the fracture has implicated this articulation. They are to be

treated by a McIntyre's splint, which is better, in these cases, than the ordinary side splints, since it permits of the free application of cold to the joint. A useful method of doing this is by means of Leiter's tubes; they can be easily applied, and possess the advantage of keeping the patient and his splint dry. Care must be taken in these cases to prevent, if possible, anchylosis taking place. It is therefore inexpedient to put the fracture up in a fixed apparatus, after all swelling has subsided, as this must necessarily embrace and fix the knee. The limb should be retained on a splint, the patient being confined to bed, and at the end of a month, or five weeks at the latest, the limb should be daily released from the splint, and the knee gently flexed. If this is done with care and caution, it will not stretch the union which has already taken place, and will prevent stiffness of the joint, which, if once allowed to form, is often extremely difficult to overcome.

Separation of the epiphysis of the upper end of the tibia is a very rare accident. As far as I am aware, the only recorded case is one by Madame Lachapelle, in which disjunction of this epiphysis took place from traction, during parturition. I do not know of any case where the lesion has been produced by violence, other than this.

Fracture of the shaft of the tibia.—When the tibia alone is broken, it is generally caused by direct violence; indirect force sufficient to break the tibia generally also causes fracture of the fibula. The fracture is almost invariably transverse when it occurs in the upper part of the shaft of the bone, and for the most part oblique when it takes place in the lower half, though transverse fracture in this part may also occur. The line of obliquity may be in almost any direction, but the most common is from above downwards and inwards, with a little inclination forwards.

When the fracture is transverse there is no visible displacement, and the patient may be able to bear the weight of his body, and walk on the injured limb, the fibula acting as a splint. Even when the fracture is oblique there is usually little displacement, the fibula acting as a stay and preventing any marked alteration in the position of the fragments. There may, however, be a certain amount of displacement, even though the fibula is not broken, especially if the fracture is near the ankle joint. The direction of the displacement varies with the direction of the fracture; but in most cases the lower fragment is displaced backwards behind the rest of the bone, and at the same time rotated slightly inwards, describing the segment of a circle around a vertical axis drawn through the inferior tibio-fibular joint. The ligaments entering into the formation of this joint limit the amount of displacement.

The signs by which this fracture may be recognised are very obscure, and it is sometimes almost impossible for the surgeon to satisfy his mind as to whether a fracture has taken place or not. The presence of a fixed pain at one particular spot in the bone, and perhaps the appearance of a linear ecchymosis after a day or two, may be the only symptoms to guide him. There may be no inequality on running the finger down the subcutaneous surface, no increased mobility, and no crepitus, and the patient may be able to bear his weight on the injured leg.

In most cases, however, a slight inequality in the outline may be perceived, and by grasping the bone above and below the painful point, a slight bending may be noticed upon pressure being made, and crepitus may be felt. When the fracture is near the ankle the diagnosis is easier, for here, by grasping and rotating the foot, the lower fragment may be moved, within certain limits, in whatever direction

the foot is forced, and often by this means crepitus is produced.

Occasionally it happens in fracture of the tibia alone, owing probably to the fact that the lesion is not discovered, and the patient allowed to get about before the fracture is united, non-union results. Under these circumstances the fibula becomes much thickened, and probably curved, and serves to support the weight of the body.

Treatment.—The treatment of fracture of the tibia alone, where the lesion occurs in the shaft of the bone, is sufficiently simple. When there is no displacement, and but little swelling, perhaps there are no cases in which the treatment by the Bavarian splint, or some other form of "movable immovable" apparatus is so applicable. The patient can then at once be allowed to get up and move about on crutches. If there should be considerable swelling, the limb may be put up in side splints, or, what is more comfortable, a roll junk, and cold lotions applied until the swelling has subsided, when the limb may be done up in the plaster of Paris or pasteboard splint, and any further confinement to bed rendered unnecessary.

Fracture of the lower end of the tibia.—The principal fracture of the lower end of the tibia is that in which the internal malleolus is broken by a direct blow. There is, in addition, a peculiar spiral fracture of the lower end of the tibia, involving the ankle joint, which has been described by French surgeons. It is produced by torsion, and as the fibula appears in most, if not all cases, to be secondarily fractured, its consideration will be deferred until we come to speak of fracture of both bones.

When the **malleolus** is broken off, it is generally displaced slightly downwards, no great amount of displacement being possible, since the fragment of bone is retained in position by the internal lateral

ligament, which is attached not only to the apex, but also to the borders of the process, and unless completely torn through would prevent any great displacement. The fracture is of importance, since it may be followed by permanent lameness or unsteadiness of gait.

The upper articular surface of the astragalus is firmly held in a sort of box, formed by the lower end of the tibia and the two projecting malleoli, which firmly grip it on either side, and serve to steady the ankle joint. If the malleolus is broken and displaced, and union takes place with the fragment in an abnormal position, as is frequently the case, or is fibrous in its character, complete integrity of the box is destroyed, and a certain amount of lateral movement is permitted in the astragalus, which gives an instability to the ankle joint and a certain unsteadiness of gait.

When the internal malleolus is broken off the nature of the injury can usually be easily ascertained by the mobility of the fragment, which can be perceived by grasping the piece of bone between the finger and thumb, and moving it backwards and forwards. This proceeding will generally elicit crepitus; but should the fragment be too far separated to allow of this being felt, a depression may be perceived above the detached fragment, which will determine the nature of the lesion.

In treating these fractures, care must be taken to push the fragment, if displaced, back into its proper position. If no displacement has taken place a pair of ordinary side splints is all that is necessary; but if the fragment is depressed an endeavour must be made, by means of a pad placed between the limb and the splint, to secure the approximation of the broken ends of the bone. This is often a matter of considerable difficulty, and requires constant care and attention on

the part of the surgeon. The union which takes place in these cases is often fibrous, but may be completely bony if the fragments are kept strictly in apposition.

Separation of the epiphysis of the lower end of the tibia appears to be a somewhat more common injury than disjunction of the upper epiphysis; two or three cases having been recorded. It is not, however, a common accident, and Dr. R. W. Smith states that it is undoubtedly "among the rarest of this class of injuries." * He has, however, recorded one case; a second case has been published by Mr. Quain,† and there is a preparation in St. George's Hospital museum which illustrates the same injury.‡

In Mr. Quain's case the diagnosis was made at the time, and was based principally on two points; first, that the prominence of the displaced tibia, which existed just above the ankle joint, was rounded and smooth, very unlike the hard, angular, sharp feel of actual broken bone; and second, that there was "an absence of the soft swelling which surrounds the broken ends of bone where any displacement exists. The preparation in St. George's Hospital is the one from which Fig. 1 was taken. In Mr. Quain's case the replacement of the bone and the treatment (by means of starched apparatus) presented no difficulty. Mr. Wood exhibited, at a meeting of the Pathological Society, a specimen of dwarfing of the tibia after separation of the lower epiphysis. §

Fracture of the Fibula.

Fracture of the fibula alone is a much more common accident than fracture of the tibia, on account of the great liability which there is for fracture to

* *British Medical Journal*, Aug. 17, 1867; p. 123.
† Ibid., Aug. 31, 1867.
‡ *See* Path. Soc. Trans., vol. iii., p. 187.
§ Path. Soc. Trans., vol. xxxi., p. 249.

occur in the lower third. In its upper two-thirds fracture of the fibula does not very frequently take place, and when it does is usually the result of direct violence, and is transverse in direction. In these cases the diagnosis is by no means easy, for there is often no displacement; the bone is surrounded by a fleshy mass of muscles, and in some instances the patient is able to walk. The main symptoms which guide us in diagnosis are the presence of a fixed pain in one particular part of the bone, which is increased upon any attempt to move the limb; the fact that the upper fragment does not alter its position with the lower upon pressing upon this part of the bone; the possible occurrence of crepitus during this manipulation, or upon rotating the foot; and the appearance of a line of ecchymosis some days after the receipt of the injury. This latter symptom may be obscured by the fact that bruising already exists, the result of the direct injury to the soft parts. If any displacement has taken place, the irregularity in the outline of the bone may be made out by careful examination.

When fracture occurs in the lower third of the fibula, the most common situation, it is generally the result of indirect violence, and is usually caused by sudden twists of the foot outwards or inwards, or by falls with the leg doubled under the patient, or falls to one side while the foot is jammed. The fracture may be produced by the foot being turned either outwards or inwards. If it is turned outwards from some sudden twist a great strain is thrown on the internal lateral ligament, and this is torn, or the process of bone into which it is inserted is broken off. The force being continued, the astragalus is pushed violently against the external malleolus, and this portion of bone being securely held by the inferior tibio-fibular ligament, the force of the injury is thrown upon the lower end of the fibula some two or more

inches above the ankle joint, and the bone gives way in this situation, the solution of continuity taking place from without inwards, and the fractured ends of the bone having a tendency to be displaced inwards

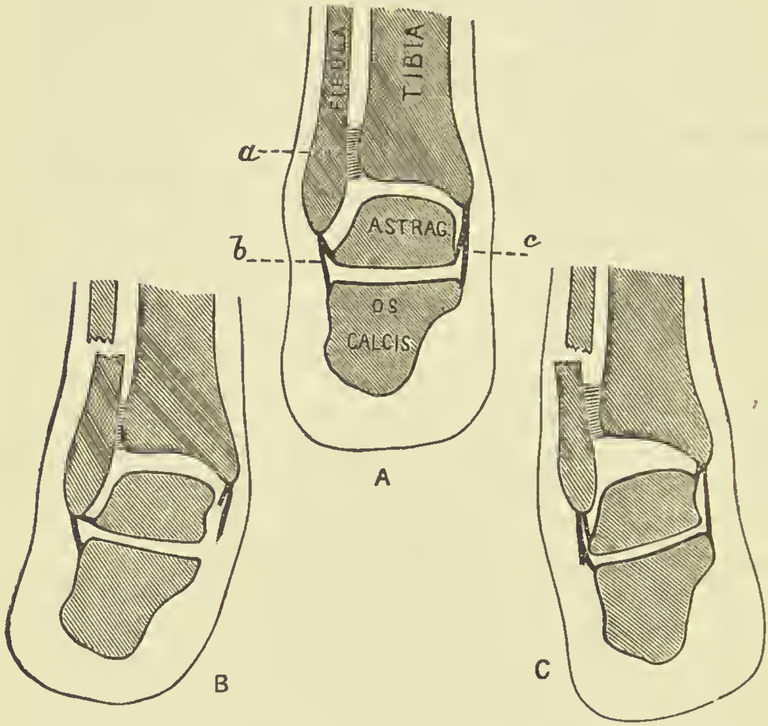


Fig. 46.—Fracture of the Lower End of the Fibula.

The figure shows the mechanism involved in fracture of the lower end of the fibula. A, Parts in normal position; *a*, tibio-fibular ligaments: *b*, external lateral ligament; *c*, internal lateral ligament. B, fracture of fibula due to eversion of the foot. C, fracture of the fibula due to inversion of the foot. (After Treves.)

towards the tibia (Fig. 46). When, on the other hand, the foot is forcibly inverted or turned inwards, the external lateral ligament is put on the stretch, and pulling on the external malleolus draws it inwards, and so forces outwards the fibula some inches above the ankle joint, and causes a fracture in this situation, solution of continuity taking place from within outwards,

and the fragments, especially the lower, having a tendency to be displaced outwards. The fracture from outward displacement of the foot is undoubtedly much the more common, though the opposite has been asserted by Dupuytren. This form of fracture is often attended with dislocation of the foot at the ankle joint, either outwards or inwards, according to the nature of the accident, but is not necessarily so. The displacement of the foot, when it occurs, seems to be the result of the continuation of the force which primarily produced the fracture, or, according to Malgaigne, is caused by efforts made by the patient to walk, in which the foot, having lost its necessary support, is turned outwards. When the dislocation outwards of the foot takes place in conjunction with fracture of the fibula, the injury is commonly known as "Pott's fracture."

Fractures of the lower third of the fibula are of more easy detection than when the lesion occurs higher up. On account of the more subcutaneous position of the bone, any irregularity in its outline is more readily detected, and crepitus is more easily obtained. Nevertheless, a fracture even in this situation cannot always be detected. There is pain, increased by pressure, over the seat of the fracture. By making firm pressure along the course of the bone with the fingers, sharp pain will be complained of upon approaching the seat of fracture, and any irregularity will be at the same time noted; probably crepitus will also be felt. When any deformity or displacement of the foot exists there is no difficulty in the diagnosis.

Treatment.—When there is no distortion of the foot, or displacement, the treatment of these cases is very simple. If there is much swelling or bruising the better plan is to simply confine the limb in a roll junk or side splints, until this has subsided, when the

leg may be put up in some form of immovable apparatus and the patient allowed to go about on crutches. If there is little or no swelling the limb may be done up at once in a Bavarian splint and all confinement to bed rendered unnecessary. In fact, these cases may fairly be treated as out-patients from the commencement, though for my own part I prefer to keep them under observation as in-patients for the first week or ten days, until it has been ascertained that the splint fits accurately, and is not either too tight or too loose. When, however, there is much displacement of the ends of the bone the case will require some more special treatment to overcome it. There are two principal plans of dealing with this displacement, which are known respectively as (1) "Dupuytren's," and (2) "Pott's method."

1. Dupuytren's method consists in applying a straight splint to the inside of the leg, which shall reach from above the knee to several inches below the foot. Between the splint and the limb a wedge-shaped pad is inserted, with the broad end downwards, and the base not extending lower than the level of the ankle joint. The upper end of the splint is now to be secured to the knee by a few turns of bandage. Finally the foot is to be made fast to the splint by a figure of 8 bandage, embracing alternately the heel and the instep. Care must be taken that the several turns of the bandage shall in no instance pass higher than the external malleolus, otherwise the object for which it is applied, namely, to throw out the upper end of the lower fragment, will be defeated. It is evident that by making the pad of sufficient thickness any amount of leverage on the lower fragment can be secured. 2. Pott's method; the patient is to be placed on his injured side, with the knee flexed, in order to relax the muscles of the calf. A side splint, with a foot piece more thickly padded than

the rest of the splint, is to be applied to the outer side of the leg, and a short splint reaching only to about the level of the ankle joint to the inner side of the leg. These splints are then to be secured by means of a bandage or webbing. The object of the thickly-padded foot piece is to turn the foot inwards and thus force the upper end of the lower fragment of the bone outwards.

Separation of the lower epiphysis of the fibula is a rare accident; as far as I am aware, the only recorded case is the one figured on page 14, in which several of the epiphyses of the lower extremity were separated, and in which also there was a compound fracture of the tibia. For these extensive injuries amputation was at once performed, and the patient died on the thirteenth day of pyæmia.

Fracture of both Tibia and Fibula.

Fracture of the leg is one of the most common forms of fracture met with in our hospitals, and in about one-half of the cases both bones are involved.

Causes. — The fracture may be produced by either direct or indirect violence. By direct violence, as by sudden blows or kicks, either from man or horse, the fall of a heavy weight upon the leg, or by the passage of a wheel over the limb. Indirect fracture may be caused by falls from a height on to the feet, jumping from a carriage whilst in motion, or by falls with the foot fixed or with the leg doubled under the patient; in fact, almost any variety of violence applied to the leg, if of a sufficient degree, will cause fracture.

It is very doubtful whether fracture of the bones of the leg is ever produced by muscular action Hamilton states that four times he has "found the bones broken by muscular action alone." I have never met with any other recorded case of fracture from muscular contraction. When the fracture takes

place in the upper part of the leg it is almost always the result of a direct blow; when it occurs in the lower third it may either be caused by direct or indirect force, the two forms of injury occurring in about equal proportions. This arises from the fact that the lower third of the bones is the weakest part, and at the same time is much exposed to injury, especially from blows or kicks.

When fracture of both bones of the leg takes place from indirect violence, it is probable that the tibia gives way first, and that the solution of continuity of the fibula subsequently ensues, in the majority of cases, at a higher level than the fracture in the tibia. The point at which the tibia gives way is generally about the junction of the middle and lower third of the bone. A glance at the tibia is sufficient to show that this is a weak spot, for the shaft gradually decreases in size from the upper end to this point and then increases again to the inferior extremity. It is therefore the narrowest part of the bone, and, like all other bones in the adult, is weakest where smallest. On section it will be seen that the compact tissue is rather thicker here than elsewhere, to compensate for the narrowing; but, according to MM. Fayel and Duret, the cancellous tissue of the bone is arranged in two columns, which meet at the junction of the middle and lower third, and, according to them, the confluence of these two columns is an additional cause of weakness of the bone in this situation. It usually happens in these cases that the fracture of the fibula is on rather a higher level than the fracture of the tibia, but this is not invariably the case. Sometimes the fractures are found to have occurred at almost, if not quite, the same level. Upon examining the fibula it will be found that the narrowest part is about four inches above the external malleolus, very nearly on a level with the weakest part of the tibia

and this is the point where fracture usually takes place when the fibula is broken alone from indirect violence. When, however, both bones are broken, the tibia giving way first, and the fibula is usually broken at a higher level.

Fractures of the bones of the leg may present great variety, both as regards their direction and condition. As regards their direction, they may be oblique, the most common variety, especially when the lesion takes place in the lower third. They may be transverse, this form being commonly met with in the upper two-thirds of the bone, when it has been broken by direct violence. Dentated and vertical fractures are occasionally met with, and a peculiar form of spiral fracture has been described by French surgeons.

These latter fractures are produced by torsion, as when a patient falls to one side, so that a rotatory movement is given to the limb, and, the foot being fixed, a sort of screw motion is applied to the bone, which results in fracture. The line of fracture is V-shaped, or wedge-shaped; and starting from the apex of the wedge, in the lower fragment, is a fissure, which passes down in a spiral direction to the ankle joint. The injury is of clinical importance, since it is always attended with considerable crushing and bruising of the medullary substance of the bone.*

In the more common form of oblique fracture of the bones of the leg, the direction of the obliquity varies; in the greater number of cases it is downwards and inwards, sometimes with a slight inclination forwards, but it not uncommonly is found to have a direction from above downwards and outwards, or downwards and backwards; indeed, the line of fracture may run obliquely in almost any direction. As regards the condition of the fracture,

* Mr. H. Morris has given an excellent *résumé* of all that is known on this subject in the "System of Surgery," vol. i., p. 1043.

on account of the subcutaneous nature of the internal surface of the tibia, it is oftener compound than any other fracture in the body, in a great number of cases the wound being produced from within by the sharp fragment of bone perforating the skin. On account of the lower part of the leg being much exposed to direct violence, fractures in this situation are very often comminuted. Multiple fractures appear to take place oftener in the tibia and fibula than in any other bones.

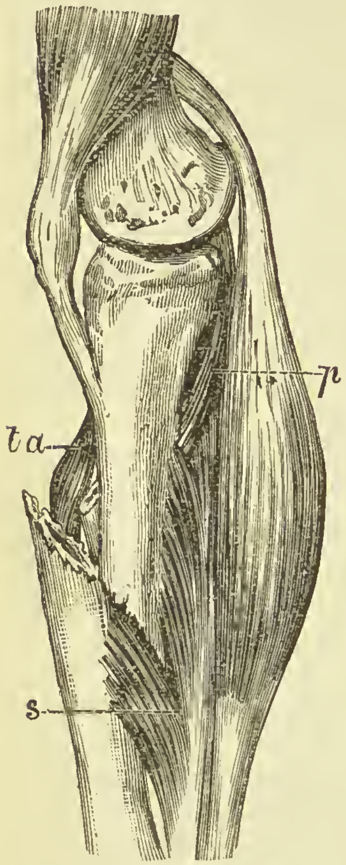


Fig. 47.—Fracture of both Bones of the Leg.

The figure shows the displacement which takes place from muscular action in fracture of the bones of the leg. *p*, Popliteus; *ta*, tibialis anticus; *s*, soleus.

When a fracture of the leg takes place in the most common situation, the prevailing displacement which occurs is that the lower fragment, with the foot, is drawn upwards and backwards behind the lower end of the upper fragment. This is brought about by the action of the powerful muscles of the calf, and is permitted in consequence of the direction of the line of fracture, when it has taken place from above downwards and forwards. If the direction of the fracture is the reverse of this, namely, from above downwards and backwards, the lower fragment is displaced forwards, its pointed extremity riding in front of the lower end of the upper one (Fig. 47). In

most cases there is also a slight amount of rotation outwards of the lower fragment; this is produced by the weight of the foot causing it to fall outwards and carrying the fragment with it, the support obtained by the continuity of the bones having become lost. "Out of nineteen specimens of united fracture of the leg," writes Mr. Shaw, "sixteen had the lower fragment rotated outwardly, and situated somewhat to the outer side and behind the upper."

In transverse fracture, especially in the upper part of the leg, where the tibia is of considerable breadth, there may be no displacement.

Symptoms.—The diagnosis of fracture of the leg, where both bones are involved, is, as a rule, easy, and there is not much probability of the lesion being overlooked. The only cases where there is any chance of this occurring is in the transverse fracture where there is no displacement. When there is any displacement, the deviation from the natural outline can be at once detected by the finger, in consequence of the subcutaneous nature of the tibia. Combined with this are the ordinary signs of fracture, shortening and deformity, increased mobility in the continuity of the bone, and crepitus. The nature of the accident may also assist us in coming to a correct diagnosis. When the fracture is in the neighbourhood of the ankle or knee joint there may be some difficulty in determining whether the articulation is involved or not. In such a case the wiser course to pursue is to assume that the joint is injured, and to adapt the treatment and prognosis accordingly. Fracture, with displacement, near the ankle joint must be distinguished from dislocation of the ankle accompanied by fracture. In the former, the malleoli retain their normal relative position to the bones of the tarsus, and the movements of the ankle joint are free. The displacement is also easily overcome, but has a

tendency to return when the extending force is removed, whereas in dislocation the reduction is difficult, but when once accomplished is permanent. The diagnosis from separation of the epiphysis has already been mentioned (page 284).

Treatment.—In conducting the treatment of fracture of the bones of the leg, as in other bones, there are two indications; first, to "set" the fracture, and secondly, to put it up securely in some form of apparatus which will retain the bones in accurate apposition. With regard to setting the fracture, it is a wise course, in the majority of cases, to do this as soon as possible, as no good can result from delay, and probably much harm. There are cases, however, in which I have thought it right to depart from this general rule. Where there has been extensive bruising of the soft part and enormous extravasation of blood, so that the whole limb is greatly swollen and feels like a bag of blood, the amount of extension necessary to obtain reduction of the displaced bone might easily cause a laceration of the skin and convert the simple fracture into a compound one. In such a case I have invariably adopted the course of putting up the limb in a roll junk and keeping cold lotions applied, until some of the blood, at all events, has been absorbed, and then, by extension, endeavoured to reduce the fracture. And I have seen no cause to regret this treatment. No doubt the difficulties of reduction are increased by delaying it; but if the fragments have not yielded to steady extension maintained for some minutes, I have generally found that the subcutaneous division of the tendo Achilles is all that is necessary to accomplish reduction.

This simple operation is one that should always be performed if any difficulty exists in overcoming the displacement; it is quite innocuous, and not only

permits of the ready coaptation of the fragments, but also renders the broken bones less liable to become again displaced, and allows union to go on uninterruptedly and without a drawback.

Another plan, which will be found useful in some cases where there is difficulty in overcoming the displacement, is to flex the thigh on the pelvis, the leg on the thigh, and the foot on the leg, and in this position to make extension and counter-extension. This will sometimes succeed when extension in a straight position has failed to effect reduction, and should always be tried before division of the tendo Achilles is resorted to.

In setting the fracture the bones must be sedulously brought into exact apposition, the foot should be kept as near as possible at right angles to the leg, and the proper line of the limb preserved. In a well-formed leg, the inner edge of the patella, the inner malleolus, and the inner side of the ball of the great toe should be in the same line. These are important points for the surgeon to bear in mind in setting a fracture, as is also a comparison with the opposite limb.

As regards the second indication; the apparatus for maintaining the bones in position are very numerous, and every surgeon has his favourite form, which he probably prefers from his having become habituated to the use of it. The ordinary practice which is adopted at St. George's Hospital is to put the limb up in a pair of Cline's side splints, and if there is no great amount of swelling they appear to answer every purpose. Some surgeons prefer a broad posterior splint, with a rectangular foot piece and two lateral splints. When there is much swelling, or when the patient is delirious, and the limb cannot be kept quiet, I know no better appliance than the roll junk. It is comfortable to the patient, does not

make any undue pressure at any particular point, but steady pressure over every part of the limb, and the patient can move his leg and the junk together, without much probability of displacing the fragments.

When there has been a great amount of displacement, it is sometimes found that this is less likely to recur if the knee is maintained in a flexed position. This object may be attained by having a short thigh piece screwed at right angles to the top of the outer side splint, which should reach just to the level of the knee joint. The patient is then to be laid on his injured side, and the knee being flexed the splints are to be applied in the ordinary way and the thigh piece bandaged to the thigh.

Some surgeons recommend continuous extension in the treatment of fracture of the bones of the leg. Dr. Packard very strongly advocates this plan of treatment, and describes and figures the way in which it may be carried out.* Perhaps the simplest plan is that recommended by Dr. Montgomery. It consists in securely strapping a flat piece of wood, cut to the shape of the sole, to the foot. A hole is bored in this piece of wood in the line of the axis of the limb, and a string, passing through it, is secured by a knot on the side next the sole before it is applied. This string is then run through a pulley fixed to the end of the bed, and to its extremity the necessary weight is attached.

In some cases, where there is great swelling and bruising, McIntyre's splint will be found very serviceable, as it leaves the front of the leg exposed and allows of the easy application of evaporating lotions. Where, however, there is great displacement and a very oblique fracture this apparatus will generally be

* *American Medical Journal*, April, 1874.
† Ibid., April, 1871; p. 357.

found inefficient in maintaining the fragments in good position.

Whatever form of splint is applied, it should be allowed to remain on until all swelling has subsided and a certain amount of consolidation of the fracture has taken place. The patient may then have the leg done up in pasteboard or plaster of Paris splints, and be allowed to move about on crutches, with the foot slung from the neck. In many cases where the fracture is transverse and there is little or no displacement and little swelling, the limb may be done up in plaster of Paris at once and all confinement to bed rendered unnecessary. Under these circumstances the Bavarian splint or the plaster of Paris splint introduced by Mr. Croft at St. Thomas's Hospital, should always be employed, since they can be removed with facility and be readjusted again without difficulty, and thus the surgeon can always have an opportunity of examining the condition of his patient's limb and of preventing those lamentable accidents which have been said occasionally to occur from encasing the leg in an immovable plaster case immediately after the accident.

Compound fracture of the bones of the leg is of more frequent occurrence than similar injuries of any other bone of the body. Agnew's tables show that in fracture of both bones of the leg about one in every three cases is compound. They may vary very much in their character, such variety depending in a great measure upon the way in which the fracture was rendered compound. In the simplest form the fracture was originally simple, but the patient in his endeavours to move, or the bystanders in their indiscreet efforts to render assistance, have caused one of the sharp ends of the broken bone to protrude through the skin. In the majority of cases it is the upper end which thus protrudes,

When the fracture becomes compound in this manner there is but little laceration of the soft parts beyond the skin wound, and if the bone has not already receded, there is but little difficulty in getting it back. The treatment in these cases is often very successful, the main object being to obtain healing of the wound, and thus convert the compound into a simple fracture. This may very often be done by causing the wound to heal under a scab; "union by scabbing," as it is generally termed. (*See* page 64.)

A severer form of compound fracture of the leg is where the extremity of one fragment (generally the upper) is protruded through the wound at the time of the accident. Here, a greater amount of violence has caused the injury, and there is consequently a greater amount of laceration of the soft parts, and the end of the bone is often denuded of periosteum to a certain extent. There is often, in these cases, a difficulty in overcoming the displacement and in returning the bone to its natural position, requiring sometimes a division of the skin, which often tightly grasps the protruding fragment; sometimes section of the tendo Achilles, when its tension appears to be the impediment to reduction, and sometimes, even, it is necessary to saw off the projecting end of the bone before the limb can be restored to its natural position. In the treatment of these cases it is hopeless to attempt the plan recommended in the former, of endeavouring to convert the compound into a simple fracture under an artificial scab. If such an attempt is made it will probably result in more harm than good to the patient. The wound will undoubtedly suppurate, and if the opening is closed, the inflammatory discharges will be prevented from escaping and will accumulate in the limb, causing it to be swollen, red, and painful, and setting up diffuse cellular inflammation, and, what is worse, perhaps, pyæmia. I have no doubt that in cases such

as these the "antiseptic" treatment of Lister is of immense advantage. It may not prevent suppuration altogether, but it undoubtedly limits it and renders it what we may term "healthy" suppuration; it prevents the presence of decomposing animal matter in the wound, which is, after all, what we have to fear.

The limb should be secured, after the fracture has been set, in a fracture box of some description, and the case dressed as recommended by Lister. By this means many of these cases may be brought to a successful termination. While giving this as the plan of treatment which, in my own experience, I have found most successful, I do not wish to dogmatise or lay down this method as the only one likely to be successful. Other surgeons have treated cases by other means with perhaps equal success, and no one plan of treatment ought to be advocated at the expense of others. What is necessary is the application of the broad principles of surgery in regard to the treatment of the case in hand. Some surgeons prefer simple water-dressing, or carbolised oil, absorbent wool, boracic or salicylic lint, and many other forms of application too numerous to mention. The main points to attend to are perfect cleanliness, daily irrigation if there is much discharge, a free exit for matter, and counter-openings if there is any tendency to bagging.

The severest form of compound fracture of the leg is where the limb has been crushed by some direct violence, as the passage of the wheel of a heavy waggon over it. In these cases the bones are extensively comminuted, the broken fragments often displaced, and the soft parts greatly lacerated and contused. In these cases the first question to consider is whether immediate amputation is necessary or not, and in deciding this, the general and local condition of the patient will have to be taken into consideration. If the patient is young, of sound constitution

and of sober and regular habits, an attempt to save the limb may be made with a far greater amount of local injury than if he is advanced in years, of broken health, or intemperate habits. Children recover from a far greater amount of injury than adults.

When it has been determined to attempt to save the limb, the wound should be thoroughly cleansed and all loose fragments of bone removed ; the bones carefully adjusted, any sharp points being rounded off with the bone forceps, and no foreign bodies or portions of soft parts allowed to remain between the fractured ends. The limb is then placed in a fracture box, and one or other of the various applications mentioned above must be applied to the wound.

The future progress of the case must be treated on general principles. Care should be taken to watch for any indication of the formation of matter, and incisions should be made if necessary. If diffuse cellular inflammation sets in, free incisions to relieve tension must be practised. If the tissues about the wound slough, charcoal poultices may be required. Perfect cleanliness should be most rigidly observed, the patient's general condition must be carefully attended to, the diet being regulated, and opiates given, if necessary, to ensure rest.

Faulty union may occasionally result either from want of proper attention in setting the fracture, or from allowing the patient to go about without any support before the union is firm, when a gradual yielding of the soft callus takes place, producing great deformity and impairment in the use of the foot. When this condition occurs in the lower part of the leg, its most usual situation, the lower end of the upper fragment will be found to project inwards, and when the patient attempts to stand the foot will be everted (Fig. 48). This condition may be relieved, to a certain extent, by a boot with an outside steel support and an inside

T-strap, so that the cross bar of the T passes around the leg, at a level with the prominent end of the bone, and buckles tightly over the steel support. In some cases it may be desirable to remove a wedge-shaped piece of bone, including the prominent portion, in order to give the patient a useful limb.

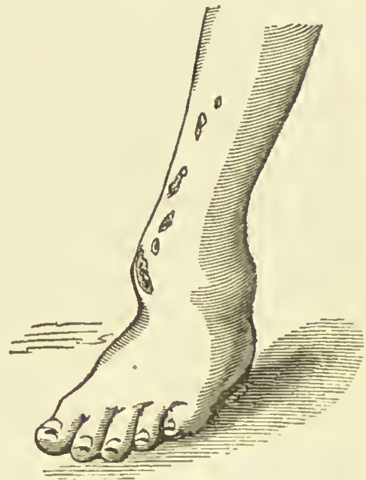


Fig. 48.—Faulty Union after Fracture of the Lower end of the Tibia and Fibula.

The figure shows the deformity which results from the yielding of callus, in consequence of insufficient retentive apparatus when the patient is allowed to get about. (From a paper by Mr. C. Heath, Clin. Soc. Trans., vol. x., p. 159.)

Fracture of the Bones of the Foot.

Fracture of the tarsal bones.— Considering the frequency with which the foot is injured, it is surprising how seldom fracture of the tarsal bones takes place. This is no doubt due, in a great measure, to the fact that the tarsus is composed of a number of bones, articulated by a considerable extent of surface, and united together by very strong ligaments, so that a certain amount of movement takes place between the several bones, which serves to break the jars which result from a fall or severe blow on the foot. It is possible, however, that fracture of these bones may occasionally occur and escape detection, the case being regarded and treated as one of sprain only. Mr. Bryant is disposed to believe that this is so, at all events, as regards the astragalus, and relates a case in which he removed the necrosed upper articular surface of this bone, the piece removed looking as if it had been fractured. The death of the bone had resulted from inflammation produced by

violently kicking against a wall.* And Mr. Morris mentions that there is in the museum of Middlesex Hospital an astragalus, the posterior and inner corner of which has been broken off.† The fracture was not detected during life, the injury being regarded simply as a sprain.

The tarsal bones, being composed of a soft cancellous tissue, covered with only a thin layer of compact tissue, when exposed to direct violence sufficient to produce fracture are sometimes extensively comminuted, the cancellous tissue being completely crushed and occasionally a species of impaction taking place. In consequence of the small amount of soft parts which covers the dorsal aspect of these bones, the fractures are often compound and associated with much laceration and bruising of the integument.

Causes.—In considering the causes of fracture of the tarsal bones, it is convenient to consider the tarsus as made up of two groups; the anterior group comprising the scaphoid, cuboid, and three cuneiform bones; the posterior group consisting of the os calcis and the astragalus.

When a fracture occurs in the anterior group it is almost invariably the result of direct violence from some crushing accident, as the passage of a heavy wheel over or the falling of a heavy weight upon the foot. When, on the other hand, a fracture occurs in the posterior group, it is for the most part the result of indirect violence, such as a fall from a height upon the feet. Probably the astragalus, except its neck, is rarely broken in any other way, though Monahan has recorded one case in which the neck was broken by direct violence; and Erichsen a second, where the same part was fractured by a cart wheel passing over the foot. The most frequent way in which the os calcis

* "Practice of Surgery," p. 965.

† *See* also *Med. Times and Gazette*, vol. ii., p. 839; 1876.

is broken is by falls upon the feet, but it is also occasionally broken by direct violence applied laterally, as by the passage of a wheel over the point of the heel while the patient is lying on the ground. Some few cases of fracture of the os calcis from muscular action have also been placed on record, where the bone has been broken by the sudden contraction of the muscles of the calf.

When the calcaneum is fractured either from direct or indirect force it may be broken in almost any direction. There may be a vertical or oblique fracture through the bone, or it may be split longitudinally, or it may be variously comminuted, with or without impaction. Malgaigne states that in all fractures of the os calcis the fracture takes place in the posterior part of the bone, and is "always situated behind the astragalus." This is, however, scarcely correct. Mr. De Meric has recorded a case where the fracture took place through the anterior part of the bone, "extending vertically between the two articulating facets."* And a second instance is recorded Dr. Uhde, of Brunswick.†

When the fracture occurs from muscular action it is vertical in direction, and is usually situated behind the astragalus. Gascoigne has, however, recorded a case in which the posterior two-thirds of the bone was separated from the anterior third. In some of these cases it would appear that a thin shell of the posterior surface, into which the tendo Achilles is inserted, has been broken off.

Occasionally the sustentaculum tali may be fractured. Abel has collected three cases of this injury.‡ He believes that it may be caused by falls upon the sole or by extreme rotation outwards of the foot, in

* *Med. Times and Gazette*, vol. ii., p. 460; 1867.
† *London Journal of Medicine*, January, 1851.
‡ *British Med. Journ.*, November 9, 1878; p. 693.

consequence of which the astragalus is forced violently against the process.

The **signs** by which fracture of the os calcis may be recognised are generally more clearly defined than those of fracture of the other bones of the tarsus, and in most cases there is no difficulty in the diagnosis when the injury has been produced by violence, either direct or indirect. There is great pain, swelling, and bruising about the heel, with marked crepitus, which is usually to be felt by grasping the point of the heel with the finger and thumb and moving it from side to side. There is often increased width of the bone, which becomes an important sign in the cases of longitudinal splitting, for in these the crepitus is often indistinct or absent. There is often, in fracture of the os calcis, a loss of the arch of the foot. When the bone has been broken vertically by muscular action or otherwise, the posterior fragment is in some cases drawn upwards by the gastrocnemius and soleus muscles, and sometimes to a very considerable extent. Cases have been recorded where this portion of bone has been felt as much as five inches above its normal position. In such cases there can be no difficulty as to diagnosis, the presence of the prominence of bone in this abnormal position at once establishes the nature of the case. In other instances no separation takes place. This is probably due to the fibrous structures around, especially those in the sole, not having been completely torn through, and so retaining the bone in position. When the fracture occurs in the anterior half of the bone, as in Mr. Gascoyen's case, the lateral ligaments of the ankle joint and the strong interosseous calcaneo-astragaloid ligament prevent anything more than the slightest displacement. In these cases, as Mr. Gascoyen has pointed out, crepitus can be felt by moving the heel from side to side and by other movements of the foot.

In the treatment of fractures of the os calcis without displacement, all that is necessary, as a rule, is perfect rest and cold evaporating lotion. It is advisable to place the limb on an outside splint with a foot piece, so as to ensure complete immobility, until all acute symptoms have subsided, when the foot may be put up in pasteboard or plaster of Paris and the patient allowed to go about on crutches.

In a fracture of the posterior part of the os calcis, with displacement of the fragment, an endeavour must be made to approximate the broken surfaces by position; that is to say, by flexing the leg on the thigh and extending the foot on the leg and fixing it by some such apparatus as is used for rupture of the tendo Achilles. A leather collar fastened round the lower third of the thigh and attached by a string to the heel of a slipper answers every purpose. The patient must, of course, be laid on his injured side.

When the fracture is compound and the fragments are loose it is advisable to remove them at once.

The neck of the **astragalus** is the weakest part of the bone, and it is here that fracture most frequently takes place. It may, however, occur in any part of the bone and in almost any direction; most commonly in a transverse vertical direction, but also antero-posteriorly or horizontally, and it may be variously comminuted. It may be broken alone, or may be associated with fracture of the other bones of the tarsus. In many of the cases of fracture the fragment is often displaced as well, leading to the symptoms of dislocation. The signs of fracture of this bone are much more obscure than those of fracture of the os calcis, and unless crepitus can be felt by moving the anterior or the posterior part of the foot, the fracture cannot usually be detected. Even if crepitus is elicited it is often exceeding difficult to localise it, or to state definitely to what bone it is to be referred. Inability

to stand on the foot, or bare pressure; deep-seated fixed pain increased on manipulation; and much swelling and bruising in the situation of the astragalus after a fall on the feet, should always lead us to suspect fracture of this bone, even though no crepitus can be felt.

Treatment.—All that is necessary in these cases, if no displacement exists, is to steady the foot on a splint with a foot piece and apply cold lotions until the swelling subsides, when the limb may be put up in some immovable apparatus. If displacement exists an attempt should be made to push back the fragment by manipulation, a proceeding, however, which often fails. It will then become a question whether its removal is necessary or not. In some instances the displaced fragment may project so much as to cause tension of the skin and threaten sloughing, under which circumstances it is advisable to make an incision with antiseptic precautions, and remove the fragment. Should there seem to be no prospect of the skin giving way, it may be allowed to remain, the foot being placed in the most favourable position in case anchylosis of the ankle joint should result.

The other tarsal bones are but rarely fractured, except in severe crushes or gun-shot injuries, and call for no special remark. They may be so comminuted, and the soft parts so lacerated, as to require amputation of the whole or a part of the foot; or, on the other hand, if injured to a less extent, may merely require rest and support, with cold evaporating lotions to effect a cure.

The metatarsal bones and the phalanges are almost always broken by direct violence, and in the majority of cases the injury is the result of severe crushing accidents, requiring amputation.

If only one bone is broken the displacement is, as a rule, only slight. I have seen, however, a case

where the second metatarsal bone was broken, and where the injury was disregarded for a week, in which the distal fragment was considerably displaced downwards and was united in this position, causing great discomfort to the patient in walking. When two or more of the bones are broken the displacement may be considerable.

When no displacement exists the treatment is very simple; rest and the support of a light splint is all that is necessary. If displacement exists it must be remedied if possible, otherwise it may prove the source of considerable annoyance to the patient.

The question of amputation must depend for an answer mainly upon the amount of laceration of the soft parts.

DISLOCATIONS.

Section III.

GENERAL PATHOLOGY OF DISLOCATIONS.

CHAPTER I.

GENERAL DIVISION AND ETIOLOGY OF DISLOCATIONS.

The word "dislocation" etymologically means "displacement" (Lat. *dis*, a preposition, denoting separation, and *locus*, a place), but in surgery it is for the most part applied to that condition of a joint in which the two articular surfaces are either partially or completely displaced from one another, and no longer occupy their normal position. The term is not, however, entirely restricted to this, but is occasionally applied to displacement of soft parts. For instance, "dislocation of the crystalline lens" is a term in daily use, and is, etymologically, strictly correct, as meaning displacement.

Dislocations, or displacements of the articular surfaces of a joint, are divided into three classes as regards their cause. (1) *Traumatic*, where the displacement has been produced by violence. (2) *Spontaneous or pathological*, resulting from gradual destructive changes in the joint and surrounding tissues, so that the bones can no longer remain in apposition, but are displaced by muscular contraction or the weight of the limb or trunk. (3) *Congenital*, arising from

some congenital defect in the joint. This third class must be distinguished from those forms of dislocation which occur during the act of parturition, from some force applied to assist or accomplish delivery, and must be regarded as a form of traumatic luxation, which may be reduced and treated in the same way as an ordinary dislocation.

The present treatise is intended only to include the first of these three classes, that is, dislocations arising from violence, the other two forms not falling within the scope of this work.

Dislocations may be complete or partial: *complete* when the two articular surfaces which enter into the formation of a joint are completely separated from each other, so as to be no longer in contact; and *partial* when the two articular surfaces are displaced as regards their normal relation to each other, but are not completely separated, so that some portion of the one articular surface still remains in contact with some part of the other. The former is the more common result in dislocations of the enarthrodial joints, the latter most commonly occurs in the ginglymoid form of articulation. Another mode of classifying dislocations is into the (1) simple and (2) compound. In the former the integuments remain unbroken, while in the latter the displaced articular surfaces are exposed by a wound, and thus air is admitted into the cavity of the joint. This distinction is of great importance, since the subsequent progress and prognosis of the case depend very greatly upon this point.

Simple dislocations will be first described, and at the end of the section a few remarks will be made on compound dislocations. To clear up the ground it is advisable to state, that in speaking of a dislocation of a bone, we allude, as a rule (to which, however, there are exceptions, *see* page 320), to the

displacement of the distal or more movable bone. Thus, in a dislocation at the shoulder joint we speak of "dislocation of the humerus," and not of dislocation of the scapula. Formerly, the proximal bones were often spoken of as being dislocated.

Causes.—The causes of dislocation must be considered under two heads: (1) the general predisposing causes which conduce to the occurrence of this lesion; and (2) the direct or exciting cause.

The predisposing causes of dislocation are various, and among them may be ranked:

1. **The nature of the joint,** both as regards its form and position. It may be taken as a general rule, that the more varied the movements of a joint, the less secure does the joint become; therefore an articulation enjoys variety of movement at the expense of safety. Thus we find that ball-and-socket joints, which from their peculiar conformation enjoy every variety of movement, are the most insecure. Again, the position of a joint, to a great extent, influences its liability to dislocation, those joints being the most frequently displaced which are the most exposed to injury. Accordingly, we find that the shoulder (a ball-and-socket joint enjoying an extensive range of motion, and situated in an exposed position) is more frequently dislocated than any other joint in the body. According to Malgaigne's tables, out of four hundred and eighty-nine luxations, no less a number than three hundred and twenty-one occurred at the shoulder.

2. **Age and sex.**—Dislocations are not common in children; in fact, with the exception of those of the elbow joint, they very rarely occur, violence to a joint or its neighbourhood being usually attended by fracture or disjunction of an epiphysis, rather than luxation. Again, in old age the bones are so brittle, and so readily give way, that dislocations are hardly

ever met with. Accordingly we find that the majority of dislocations occur in adult or middle-aged subjects. Hamilton says that they are very rare in infancy and up to the age of five; they then gradually increase in frequency up to fifteen, then more rapidly up to sixty-five, after which they decline, and become very uncommon. These conclusions are based on Malgaigne's tables of six hundred and forty-three cases.* As might naturally be expected, dislocations are much more common in men than in women, on account of the nature of their respective employments, and the greater exposure of the former to serious injury.

3. **Constitution and condition of structures around a joint.**—There can be no doubt that persons of feeble constitution, or those whose muscular system has been wasted by disease, are more prone to suffer from dislocation from an injury than those of robust constitution and whose muscles are in a healthy condition. So, again, patients in whom the ligamentous structures around a joint have been stretched, either by effusion or by violent extension, are very liable to dislocation. Or, again, the ligaments connecting the articular surfaces may have been torn by some previous injury, and thus occasion a tendency to dislocation. Accordingly, we find that a former luxation is a very potent predisposing cause.

Direct or exciting causes.—These are the same as the exciting causes of fracture; namely, violence and muscular action; the latter is, however, even a far less common cause in producing dislocation than it was found to be in occasioning fracture. The violence, as in fractures, may be of two kinds, either direct or indirect. The former where a blow or injury is applied directly to the joint, forcing the articular surfaces asunder. Thus a blow on the front of the

* "On Fractures and Dislocations." p. 494. 1871.

shoulder joint may force the head of the humerus backwards and produce one of the forms of luxation of this articulation. Dislocation from indirect violence is, however, much more common. Here the force acts at some distance from the joint implicated, and is transmitted along the shaft to the head of the bone, forcing it out of its socket. Thus a fall on the hand or elbow, with the arm separated from the side, is a frequent cause of dislocation of the humerus. Muscular action very rarely produces dislocation, except in some particular joints, as that of the lower jaw and the patella, though some few cases have been recorded where some large joint, especially the shoulder, has been dislocated by a violent muscular contraction, even although the joint was presumed to be healthy. Where, however, an articulation has been weakened by disease, or its ligamentous connections stretched by previous effusion or former injury, muscular action is very liable to produce dislocation. Occasionally, individuals are able to produce a dislocation, or at all events a partial dislocation, by a voluntary muscular effort. This is especially common in the metacarpo-phalangeal joint of the thumb.

One very decided influence the muscles possess in regard to dislocations, and that is in producing a further displacement of the head of the bone after it has once been thrown out of its articular cavity. This is due to the continued contraction of the muscles, which goes on for some days after the injury, and by constant traction on the displaced bone alters its position, so that after the lapse of a certain time, if the dislocation is allowed to remain unreduced, it will be found to be in another place than the original position in which it was first discovered

CHAPTER II.

EFFECTS AND COMPLICATIONS OF DISLOCATION.

The effects of a dislocation upon the structures entering into the formation of a joint, or in its immediate neighbourhood, are always of importance and frequently serious. The bones, ligaments, muscles, vessels, and nerves, may all suffer. The bones are not uncommonly fractured, as well as dislocated; in fact, in some joints, notably the ankle, dislocation rarely occurs except when complicated with fracture. The enarthrodial joints are much more likely to escape this form of injury than the hinge joints, where fracture is a not unfrequent accompaniment of dislocation. The fracture may vary from some chipping off of a small fragment of the articular surface or fracture of some neighbouring process, to extensive comminution of the end of the bone. In complete dislocations the ligaments are more or less torn, but in partial dislocations they appear to escape sometimes with stretching and without laceration. The amount of tearing depends to a certain extent on the nature of the joint, the capsular ligament in an enarthrodial joint being much more extensively lacerated than the ligaments which bind the articular surfaces of a ginglymoid joint together. In some rare instances the capsular ligament appears to escape laceration but only because it has been torn away from its attachments. Mr. Eve has placed on record such a case.* The muscles which surround the joint are often much bruised and lacerated, and

* Med.-Chir. Trans., vol. lxiii., p. 318.

sometimes tendons in the neighbourhood, especially those which are connected with the capsule, are torn across. On account of their elasticity the large arteries in the vicinity of a joint generally escape injury when dislocation occurs, though the axillary artery has been occasionally injured in luxations of the shoulder joint. The vessels may, however, be compressed by the displaced head of the bone, and all circulation through them stopped. Nerves in the neighbourhood of a joint are frequently injured when the bones are dislocated. This is especially the case with the circumflex nerve of the arm, which, winding around the shoulder joint, is exposed to injury in displacement of the head of the humerus. They may be contused, lacerated, or simply compressed, leading to intense pain at the time of the injury, and subsequently to paralysis of the muscles which they supply. When the dislocation is simple and has been speedily reduced, most of these injuries are soon repaired and no permanent lesion in many cases remains. In some instances the functions of the joint may never become thoroughly restored. The capsular or other ligaments may become contracted, interfering with the free movements of the articulation, and this is especially likely to occur if passive motion is too long neglected. Or the injured muscles may never regain their former condition and strength, but may remain permanently weakened, and thus interfere with the comfort of the patient and the usefulness of the limb. The joint itself may be also weakened, rendering a recurrence of the dislocation a matter of extreme probability, even from the slightest amount of violence. This is particularly likely to occur in certain joints, where the articular surfaces are but ill adapted to each other, and where the main strength depends on the ligaments, such as in the sterno-clavicular and acromio-clavicular joints.

Among the graver evils of dislocation are those where an artery has been injured, leading to its total occlusion and obstruction of the circulation through the limb, followed by gangrene, or to the formation of a traumatic aneurism. * Or where a nerve has been injured and its function is never restored, leaving complete paralysis in the parts supplied by it.

When a dislocation remains unreduced, certain changes take place both in the old cavity and also in the displaced end of the bone and the tissues on which it rests, in order to adapt them to their new relations and to permit of a certain degree of motion between the bones in their new position.

In the ball-and-socket joints the old cavity becomes gradually filled up with a fibroid material; its circumference becomes contracted and less regular, until at length no remains of the original cavity exist. The time which this takes is uncertain; the changes are probably very slow, but more rapid in children and young persons than in the adult. Fournier records a case in which the acetabulum retained its form and depth and was still coated with cartilage, though the head of the femur had been dislocated for thirteen years. † And it is probable that in some cases the changes above enumerated as taking place in the old cavity never occur, but that it retains its depth and remains covered with cartilage throughout the rest of the life of the patient, the occurrence of the changes being probably due to the violence of the injury it has sustained at the time of the accident, and to the consequent inflammation.

In the hinge joints the articular ends are altered in shape so as to be scarcely recognisable, the bony processes become rounded off and the extremities of the bones present a stunted, angular outline. The

* See *Amer. Journ. Med. Sciences*, July, 1860; p. 30.
† *Bulletins de la Société Anatomique*, 1855.

cartilages covering them become metamorphosed into connective tissue.

There are also great changes in the tissues against which the extremity of the displaced bone rests; they become hollowed out into a cavity, which forms a receptacle for the bone and becomes lined with a dense fibroid material, which sometimes partially

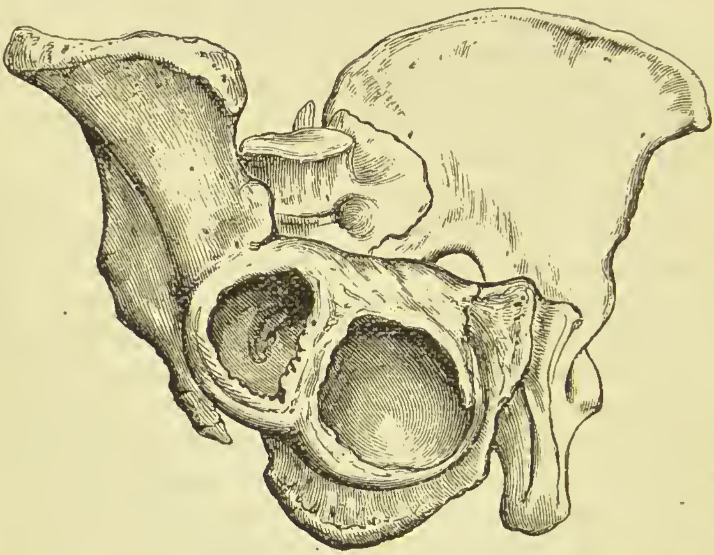


Fig. 49.—Unreduced Dislocation of the Femur.
The acetabulum has been partially filled with a dense fibroid material, and a new cavity formed for the head of the thigh bone. (After Astley Cooper.)

ossifies, so that it forms a kind of bony articular fossa (Fig. 49). The head of the bone becomes at the same time altered in shape; its incrusting cartilage becomes absorbed and the bone eburnated, or else the cartilage becomes filamentous, first presenting the appearance of fibro-cartilage and afterwards of ordinary dense connective tissue.

The cellular tissue around becomes infiltrated with plastic matter and converted into cicatricial tissue, and thus a newly formed capsule is developed around

the ends of the bones. If passive motion is persevered in a synovial sac becomes developed within the capsule, and thus a very fair joint, with a considerable range of motion, is gradually formed. In some cases even, if the new joint is diligently used, cartilage may be reformed within the cavity and over the head of the bone, thus adding to the perfection of the joint.

Secondary changes take place in the neighbouring structures; the muscles shorten and atrophy, and, if disused, undergo fatty degeneration. If they or their tendons have been torn away they form fresh attachments. Occasionally ossific deposit takes place in the tendons, and this may to a certain extent interfere with the future movements of the joint. Vessels and nerves may become incorporated in the altered structures in the neighbourhood of the new joint, and their functions partially interfered with.

The amount of utility of the limb which will be subsequently obtained when a dislocation has been left permanently unreduced will depend very much upon the nature of the joint that has been implicated. Very much greater freedom of motion can generally be obtained in an unreduced dislocation of the enarthrodial variety, than of the ginglymoid joints.

In these latter the amount of impairment of movement is oftentimes very considerable, so as to render the limb almost useless, whereas in the ball-and-socket joints, and especially the shoulder, the range of movement is sometimes so good that the patient does not appear to suffer any inconvenience from his defect.

Dislocation may be complicated by fracture of the shaft of the bone dislocated. In these cases there can be no doubt that every effort should be made to effect a reduction of the dislocation at once. The

treatment to be adopted must vary, according as to whether the fracture is through the shaft of the bone at some distance from the dislocated head or whether it is through the neck of the bone, so that only a small fragment is separated and displaced from the rest.

In the former case the fracture must be first put up very firmly indeed, in four short wooden splints which completely encase the limb, so that when fixed they shall securely grip the part. The patient must then be placed thoroughly under the influence of an anæsthetic, and when the muscles are completely relaxed an attempt must be made in the ordinary way, using the limb encased in splints as a lever, to reduce the dislocation. When the fracture is in close proximity to the joint, it is better not to employ any splints, which will only be in the way and cannot be used as a lever, since they cannot be made to fix the upper fragment. The muscles having been thoroughly relaxed with chloroform or ether, the surgeon must endeavour by manipulation, by gently kneading and pushing the head of the bone, to press it back into its proper position. This can frequently be accomplished by perseverance, the main obstacle being the difficulty in returning it through the rent in the capsule, so that pressure should always be made in the contrary direction to that in which the head of the bone is supposed to have travelled. After the dislocation has been reduced the fracture is to be put up and treated in the ordinary manner. In these cases a greater amount of rigidity and impaired movement must be expected, since passive motion cannot be commenced so early as in uncomplicated dislocation. Sometimes a fracture extends into a joint which has been dislocated, especially in the elbow and ankle. Here great care must be taken to procure and maintain exact apposition of the

fractured bones after the dislocation has been reduced. And gentle passive motion, if it can be done without disturbing the fracture, should be commenced very early, as there will always be, in these cases, a great tendency to fibrous anchylosis.

CHAPTER III.

SYMPTOMS OF DISLOCATION.

In the majority of cases the symptoms of dislocation, as described in our text-books, are so clear and well defined that it seems surprising that there should be any mistake as to their diagnosis. But it must be in the experience of every surgeon that these injuries are frequently overlooked; and it must be confessed that though the symptoms as laid down in writing appear to be sufficiently clear and straightforward, that in actual practice and in the clinical examination of cases, difficulties not uncommonly present themselves; and it is one thing to detail on paper the signs of a typical displacement, and another thing in practice to apply the symptoms which have been there detailed. On account of the dislocation being often complicated with other injuries, the depth of the part, and the swelling and effusion which take place, there is often the greatest difficulty in coming to a certain conclusion as to whether any displacement has taken place, and the best-informed and most painstaking surgeons may be led into error, or may be compelled to confess that they are in doubt as to the exact nature of the injury.

The general symptoms of a dislocation are (1) pain in and around a joint, following an injury, which

is usually of a severe nature; though in cases where the joint has been previously injured the accident may not have been of a very serious nature; (2) impaired power of voluntary motion on the part of the patient, and, conjoined with this, if the muscles and ligaments about a joint have been extensively torn, increased freedom of passive motion, and some movements which, limited or impossible in the healthy condition, are now possible; (3) there is a change in the natural shape of the joint. This is due to an alteration in the position of the displaced bone, and in the position and relation of the muscles in the neighbourhood of the joint, and also later on to swelling and effusion. There is also discoloration, sometimes not showing itself for some days, from extravasated blood; (4) there is an alteration in the relation of the bony prominences about the joint, when compared with those on the opposite side of the body; (5) the displaced end of the bone can sometimes be felt in its new situation. This, when present, is an important and characteristic sign, but it is not always to be felt. Thus, in dislocations of the shoulder in the subclavicular form of the injury, the head of the humerus can be plainly perceived on the front of the chest beneath the clavicle, whereas in the subcoracoid variety the bone can scarcely be felt, or if the patient is very fat, cannot be felt at all. So in dislocations of the hip, the head of the bone can be easily felt in the suprapubic luxation, and with difficulty or not at all in the dislocation into the sciatic notch or on to the dorsum of the ilium; (6) there is an alteration in the length of the limb, when compared with that on the other side of the body. In the great majority of cases the limb is shortened, but this rule is by no means absolule; in a certain proportion of dislocations lengthening takes place; (7) there is finally an alteration in the direction of the axis of the displaced bone.

These two last signs are of especial importance in determining the variety of dislocation which has taken place, though, of course, they are also of use in determining the prior question of the presence of a dislocation. That is to say, given a joint in which we have arrived at the conclusion that there is a luxation, we shall depend mainly on the amount of shortening or lengthening, and the direction of the axis of the bone in determining what form of dislocation exists.

The chief points by which dislocations are to be distinguished from fracture are the diminished mobility, the absence of crepitus, and the fact that when the deformity is once reduced it does not as a rule return without some fresh violence, or, at all events, movement of the joint; whereas in fracture there is preternatural mobility; crepitus; and the fragments after reduction will not remain in position without artificial support, but the deformity speedily recurs, even though no movement of the limb is made. No one of these symptoms, taken alone, is sufficient to establish the diagnosis between fracture and dislocation; but the sum of the three signs must be taken. For preternatural mobility may, as as we have seen, exist with dislocation, where the ligaments and muscles around a joint have been much torn. Again, crepitus, or pseudo-crepitus, may be felt in dislocation, and may lead to error, if relied upon alone as a diagnostic symptom. This sensation may be caused in several different ways. True bony crepitus may be felt if the displaced bone rests against any fractured bone in the neighbourhood. For example, the head of the humerus may rest against a broken coracoid process, and by moving the arm crepitus may be felt, which is often apparently due to fracture of the humerus; or, secondly, a very minute fragment or scale of bone may be torn off with some detached tendon or ligament, and may give rise to

crepitus. Pseudo-crepitus may be mistaken for true crepitus. This sensation is due to the presence of lymph in the joint cavity or sheaths of the neighbouring tendons, and though generally easily distinguishable from true crepitus, may be mistaken for it. Finally, at a later period of the case, the cartilage and soft parts covering the end of the bone may be absorbed, and in this way the exposed bone, when moved, may grate against neighbouring tissues, and crepitus be produced. Lastly, it is not in every case of fracture that displacement recurs after reduction; nor, conversely, does every case of dislocation manifest a tendency to remain without recurrence after reduction has been effected.

CHAPTER IV.

TREATMENT OF DISLOCATIONS.

When the diagnosis of dislocation has been established, the first indication is to effect reduction as speedily as possible. If this is done at once, it may often be accomplished without any difficulty. One of the main impediments to effecting reduction is muscular contraction, and immediately after the accident the patient is faint and his muscles relaxed, so that it often happens that the patient himself, or some bystander, may accomplish reduction, simply by pulling or moving the limb; whereas in the course of a short time the muscles are thrown into a condition of spasmodic contraction from reflex irritation, and can then only be overcome by the exercise of a very considerable force, or by the paralysing influence of anæsthetics. If, therefore, the case is seen by the surgeon almost immediately after the accident, and

while the patient is still faint and his muscles relaxed, reduction should be at once attempted. If the case has not been seen for some hours after the accident, it is always advisable to administer an anæsthetic at once, before any attempt at reduction is made. In no class of cases in operative surgery is chloroform or ether of more value than in the treatment of injuries of this nature. In a few minutes the muscles of the strongest man may be rendered powerless, and any difficulties in effecting reduction will depend alone on the resistance arising from the anatomical structure of the joint, and be due entirely to mechanical causes.

There are two principal modes of reducing dislocation, viz. by (1) manipulation and (2) extension.

Reduction by manipulation.—The object of this plan of treatment is to effect reduction by employing certain movements of the limb, which shall relax the ligaments and disentangle the bones from each other, and cause the head of the displaced bone to retrace its steps into its socket; or put it in such a position as shall enable the muscles by their contraction to draw it back again into its proper place. It is especially applicable in those cases where the obstacle to reduction depends upon some interlocking of the bones, or where the displaced bone is prevented from returning by misplaced ligaments, or by some obstruction at the rent in the capsule through which it has passed. In these instances, by gentle movements of the limb the head of the bone may be made to retrace the course it has taken, and reduction is effected without exerting that amount of force which is necessary to overcome the resistance of capsular entanglement by forcible extension. Many dislocations, especially those of the shoulder and hip, may be promptly reduced by this means alone, which should always be preferred, as less likely to inflict additional injury to the patient.

Reduction by extension.—The second method is by extension and counter-extension, and has for its object the overcoming of the muscular and other resistance by a superior force. The counter-extension is made by the hands of an assistant; or by a belt or jack-towel fastened round the limb or body of the patient above the dislocated joint and fixed to some immovable object; or by the surgeon himself by means of his knee or foot, with which he fixes the injured joint. The extension is made by the hands of the surgeon or an assistant grasping the limb below the seat of dislocation; or by means of a bandage or jack-towel fixed to the limb by a clove hitch, by which a firmer grip may be obtained; or by passing the towel over the shoulders of the operator, by which means a greater amount of extending force may be exercised for the strong muscles of the back can then be brought into play. If still more force is required, some form of multiplying pulley, that is, a system of pulleys on a single string, must be employed. In order to apply the pulleys, the trunk of the patient, or the limb above the seat of dislocation, is first to be fixed, by means of a broad well-padded leather belt, to a staple driven in the wall or some immovable piece of furniture. The limb is then to be bandaged with a damp roller, to avoid the consequences of pressure and prevent slipping, and the pulleys fixed to it by a leather collar, while the other end of the pulleys is attached to a fixed staple opposite the first one. The string of the pulley is to be cautiously and gradually tightened so as to make continuous and steady traction on the dislocated joint. As regards the amount of power which may be employed without doing any damage, we are at present in doubt. Malgaigne lays down the rule that we should never employ a greater force than 440 pounds; and the French surgeons are in the habit of using an

instrument, called a dynamometer, attached to the pulleys, by which the force employed in the extension can be measured. While this process of extension is going on the surgeon manipulates the bone, and by means of rotatory or other movements endeavours to coax the bone back into its proper situation, or tries to lift it over the margin of the empty articular cavity. Should he fail in doing this, after sufficient extension has been made, in his judgment, to bring the head of the bone over its articular surface, the pulleys are suddenly relaxed, and by a rapid lever-like movement he endeavours to force the head of the bone into its normal position. As regards the length of time during which such forcible means are allowable, the surgeon must in the main be satisfied to use his own judgment. Great damage may be done by too prolonged or too severe extension, and still the surgeon will feel loath to leave the patient to his fate. Certainly, persevering attempts made for half an hour without success would justify him in believing that at all events the plan adopted would not answer, and that he must resort to other measures. If some weeks have been allowed to elapse before reduction has been attempted, the permanent secondary shortening of the muscles and the matting together of the tissues will render the treatment of the case more difficult. Free passive motion will have first to be applied in order to break down these adhesions and free the bone, and unless this is done very thoroughly all efforts at reduction by extension will be futile. Other instruments have been introduced for the purpose of making extension instead of the multiplying pulley. Of these, perhaps Bloxam's dislocation tourniquet is the most convenient; by it any amount of extending force can be easily applied and maintained (Fig. 50). Jarvis's adjuster is another means by which a very powerful force can be applied. Perhaps the most useful suggestion,

however, is that of Dr. Gilbert's, of Philadelphia. He proposes a form of apparatus which may advantageously be employed in cases where the pulleys are not at hand. "Place the patient and adjust the extending and counter-extending bands as for the pulleys; then procure an ordinary bell-cord or a wash-line, tie the ends together and double it upon itself, pass it through the extending tapes or towels, doubling the whole once more, and fasten the distal end, consisting of four loops of rope, to a window-sill, door-sill, or staple, so that the cords are drawn moderately tight; finally pass a stick through the centre of the double rope, then, by revolving the stick as an axis or double lever, the power is produced precisely as it should be in such cases, viz. slowly, steadily, and continuously." *

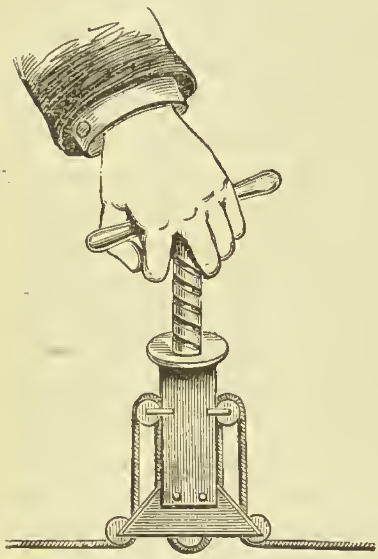


Fig. 50.—Bloxam's Dislocation Tourniquet.

In applying extension it is usually the wiser plan to attach the pulleys to the actual bone that has become displaced; that is, to the lower end of the humerus in dislocations of the shoulder, and to the lower end of the femur in dislocations of the hip, and not to the farther end of the limb; by applying the extending force in this way the surgeon has more command over the limb, and there is less chance of doing injury to intervening parts. It has been said that by applying the pulleys to the distal end of the limb we get a longer leverage; but it must be borne

* Hamilton, "Fractures and Dislocations," p. 500. 1871.

in mind that it is a broken lever, and the advantage to be gained from such a mechanical aid do not counterbalance the great disadvantage of probable injury to intervening joints.

An important point in the treatment of dislocations is the conduct of the case after reduction has been accomplished, and the surgeon will have to be careful to keep the joint quiet for a time to prevent a recurrence of the dislocation, and at the same time will have to avoid the opposite extreme of allowing the joint to remain too long unused and thus cause permanent loss of motion from fibrous anchylosis. There is no doubt that it is absolutely necessary to carefully maintain the position of a joint after reduction by bandages or splints, otherwise the end of the bone may easily slip out again, the ligaments which should retain it in position being stretched or torn; but there is, I think, a tendency sometimes to maintain this fixed position for too long. The fear of a recurrence is so great that the limb is kept immovably fixed for so long a time that fibrous adhesions in the joint take place, or it may be the capsular and other ligaments become contracted and shortened, and thus the freedom of movement in the articulation is interfered with, and is, in some cases, very difficult or impossible to thoroughly restore. After the joint has been kept quiet for a few days, until all effusion has been absorbed, passive motion should be resorted to daily, and if this is done by the surgeon gently and with care it can be accomplished without any fear of a repetition of the displacement. Between the visits of the surgeon the limb should still be kept bandaged, and the joint fixed, so as to prevent any incautious movement on the part of the patient, which would be much more likely to produce a recurrence of the dislocation than the cautious and well-regulated movements of the surgeon.

If from any cause the surgeon fails to accomplish reduction, after repeated attempts, and every procedure has been adopted that can be suggested (a circumstance that occasionally happens to the best and most skilful operator), every endeavour must be made to give the patient as useful a false joint, with as great an amount of movement, as is possible ; and by diligent and persevering efforts it is astonishing what a considerable range of motion may be obtained, at all events in the enarthrodial joints, such as the shoulder and the hip. In the ginglymoid joints the result is not so favourable, and the amount of motion which can be obtained not so great.

If a dislocation is left unreduced for some considerable time the changes already alluded to take place, and the difficulties in then effecting a reduction are oftentimes very great, and indeed sometimes insurmountable. The obstacles to reduction are due partly to the condition of the neighbouring muscles, for not only are they shortened by a condition of powerful tonic contraction, but they have also undergone considerable organic change, been infiltrated with inflammatory products, which render them tense and unyielding, and often shortened by the contraction of the cicatricial tissue, which has formed as a means of repair when they have been lacerated. Another obstacle to the reduction of an old dislocation is the presence of adhesions which have formed between the end of the displaced bone and surrounding parts, and which are often very dense and unyielding, and unless completely broken down before any attempt is made at reduction, entirely prevent the replacement of the bone in its natural position. Finally, the changes which have been described as taking place in the empty articular cavity, whereby it becomes lined, and, it may be, filled up with some fibroid material, offer an important obstacle to the reduction of a dislocation, and

would, even if the bone were restored to its normal position, prevent the natural functions of the joint from being completely restored.

As regards the time at which all attempts to reduce a dislocation should be abandoned, the introduction of anæsthetics compels us very considerably to modify the old rule, originally laid down by Sir Astley Cooper, that it was improper to attempt the reduction of a dislocation of the shoulder which had existed for a longer period than three months, and of the hip that had been allowed to remain unreduced for more than eight weeks. In coming to a decision in any particular case as to whether attempts should be made to effect reduction, there are several circumstances which require consideration; and, first, the nature of the joint. In a ball-and-socket joint the amount of motion which may be obtained, and therefore the consequent utility of the limb, if a dislocation is left unreduced, is very much greater than would be, in a general way, obtainable in a displacement of a ginglymoid joint.

Again, the amount of pain produced by any attempt to move the displaced bones on each other should be an indication as to the desirability or not of attempting reduction. If movement is painful, the patient will not be induced to exercise his joint sufficiently freely, and if this is not done no false joint will form. So that when any pain exists it is better to make an attempt at reduction in cases where, if no pain existed on movement, perhaps the wiser course would be to leave the dislocation unreduced and endeavour to establish as useful an artificial joint as possible.

In attempting to reduce an old-standing dislocation, the patient having been thoroughly anæsthetised, all adhesions must first be completely broken down by movements of the limb in every direction.

This must be continued until the end of the bone can be felt to move quite freely in its misplaced position. Some surgeons recommend that after this has been done all efforts at complete reduction should be postponed for a day or two; but it seems better in the majority of cases, at all events, to proceed at once to the attempts at reduction. The breaking down of the adhesions is sure to be followed by a certain amount of swelling and pain, and if the surgeon waits till this has subsided fresh adhesions may have formed. Occasionally it will be found that no amount of passive motion is sufficient to entirely free the head of the bone, and tense bands of adhesion or stretched tendons may be felt in the neighbourhood of the joint which prevent the free movement of the bone. Under these circumstances, the plan originally proposed by Dieffenbach must be adopted. This consists in subcutaneously dividing these tense structures. If this is done, the small punctures should be allowed to heal before any attempt is made at reduction. When the movements are quite free, reduction is to be attempted by manipulation, or by extension and the use of the pulleys. The former method should always be had recourse to in the first instance, and will often succeed, for violent extension may often do very considerable damage, and should never be employed until the milder measures have failed.

Compound dislocations.—A compound dislocation is one of the most serious accidents which can befall a limb. It is generally complicated with other injuries, for not only is there often extensive laceration of the soft parts which cover the joint, but frequently important vessels and nerves in the neighbourhood are injured, and the bones entering into the formation of the joint fractured.

The injury is attended with the most severe form of inflammation, which rapidly runs on to suppuration

and complete destruction of the joint, so that bony anchylosis is the most favourable result which can ensue. If, however, the joint is small, as one of the phalangeal articulations, the injury may be recovered from without destruction or loss of motion.

Treatment.—It must be remembered that the injury itself does not call for amputation, except perhaps in the knee, in which it is almost invariably necessary. Sir Astley Cooper states that he knows no accident that more imperatively demands amputation than compound dislocation of this joint. On account of the amount of injury and laceration of the ligaments and muscles in the neighbourhood, reduction can usually be accomplished with ease, and the bones can readily be replaced in their normal position. If the joint is a small one, or if the dislocation is not complicated with much injury to the soft part, or by fracture, after reduction has been accomplished the limb must be securely fixed on a splint, or in some apparatus, in the most favourable position for anchylosis. Every part of the joint must be thoroughly syringed out with a solution of carbolic acid, all foreign bodies having first been carefully removed. A drainage tube (one of horse-hair is to be preferred) having been inserted, the external wound is to be closed with sutures and the joint dressed with antiseptic dressings. Some surgeons, instead of this form of dressing, prefer the persistent application of cold, either by irrigation or ice.

If the dislocation is complicated with much injury to the soft parts or with fracture, the question of excision or amputation will arise. In determining between the two operations a great deal will depend upon the joint involved. Those of the upper extremity, and especially the elbow, are particularly suitable for excision, and, provided the soft parts are not very extensively lacerated, the operation holds out a very

fair prospect of success and recovery with a considerable range of movement. In the lower limb, on the other hand, where bony anchylosis is desirable, excision is not such a favourable operation; and in these cases, supposing reduction can be accomplished without difficulty, and there is not such an amount of laceration as to render amputation necessary, it seems better to abstain from excision and to treat the case as one of fracture, with wound of the joint, and endeavour to obtain bony anchylosis. In other words, it is better to excise the ends of the bone in a joint where movement is desirable, and abstain from operation where bony anchylosis will give the patient the more serviceable limb.*

In old and debilitated people, or in those whose constitutions are unsound, it is better to resort to amputation at once.

* An exception to this rule may, perhaps, be made in regard to dislocations of the ankle joint.

Section IV.

SPECIAL DISLOCATIONS.

CHAPTER I.

DISLOCATION OF THE LOWER JAW.

THE temporo-maxillary joint permits of only one form of dislocation, unless attended with fracture,* and this is in a direction forwards. It presents two different forms, namely, (1) where both condyles are displaced (the "bilateral" dislocation), and (2) where one condyle only is separated from its articular cavity (the "unilateral" dislocation).

Of the two forms the bilateral is much the more common. Of seventy-six cases collected by Malgaigne, fifty-four were bilateral. These figures pretty well agree with the statement of Hamilton and Bryant, that the bilateral dislocation is met with in two out of every three cases. Nélaton believes that the proportion is very much less, and that the frequency of the bilateral is not much greater than that of the unilateral dislocation. There is no doubt that the injury is much more common in women than in men, and appears to take place most frequently during the middle period of life; though cases of dislocation both in young children and in old people, with jaws edentulous from age, have been recorded. The probable cause of this greater frequency of dislocation in middle life is probably due to the shape of the

* A case is recorded by Robert of displacement outwards, accompanied by fracture.

jaw at this period, so that the muscles act with greater leverage, and no doubt also are possessed of greater power. In addition to this, injuries of all kinds are more common at this period of life than in the very old or the very young.

Causes.—Dislocation can only take place when the mouth is widely open. When the action of opening the mouth takes place, the condyle of the jaw advances upon the eminentia articularis. It does not quite reach the summit, but under ordinary circumstances stops short of this point, its further advance being prevented by the hindermost fibres of the lateral ligaments, especially the external, and by the posterior part of the capsular ligament. When the condyle of the jaw is in this position it may be dislocated either by muscular action or by violence. By *muscular action,* from the spasmodic contraction of the external pterygoid, which, already in action, may, by a further contraction, pull the condyle over the summit of the ridge, and thus produce dislocation. The luxation may thus occur during the act of yawning, vomiting, and shouting, and having once taken place, is very likely to recur during the performance of any of these actions. By *violence* the jaw may be dislocated, when the mouth is wide open, either by a force acting from without, as a blow or kick; or by a force acting from within the mouth, tending to force it more widely open. Thus, dislocation has been known to occur during the extraction of teeth, from taking a cast of the mouth, or in passing a stomach pump tube. In the well-known case of Sir Astley Cooper's of dislocation in a child, the lesion was produced by the endeavour on the part of a child to force an apple into its mouth.

When dislocation has taken place, the condyle of the jaw, with the interarticular fibro-cartilage, which

is displaced with it, becomes lodged in front of the anterior root of the zygoma or eminentia articularis (Fig. 51), and being drawn upwards and forwards by the masseter and internal pterygoid muscles, becomes fixed in this position. This fixation of the jaw is one of the constant characteristics of the dislocation,

Fig. 51.—Dislocation of the Lower Jaw.
Showing the position of the condyle of the jaw in dislocation forwards.

and its cause has been the subject of considerable discussion.

By Nélaton, who has paid great attention to this subject, and by some others, it is believed that this fixed condition of the jaw is due to the fact that the summit of the coronoid process abuts against the malar bone, and that this prevents reduction until it has been forced back again.

In the majority of cases, however, the coronoid process is not sufficiently long to reach the malar bone in the ordinary dislocation, without such a tearing of the structures about the joint as does not usually

exist. Probably in some cases the fixation and difficulty in reduction may depend upon the coronoid process becoming entangled in the fibres of the temporal or masseter muscle.

The dislocation appears to take place without any great laceration of surrounding structures. With the exception of perhaps a slight tearing of the capsule of the joint, the ligaments appear to escape injury; they are much stretched, but not torn, and the ligaments being thus tense may present a certain obstacle to the replacement of the bone. The direction of the fibres of the external lateral ligament is reversed; instead of passing in a direction downwards and backwards, they now pass downwards and forwards. The internal lateral and stylo-maxillary ligaments are tightly on the stretch, and their tension is increased by raising the chin, but they do not as a rule give way.

Symptoms.—When the dislocation is *bilateral* the mouth is wide open, the incisor teeth of the two jaws being separated from each other to the extent of an inch, or an inch and a half; those of the lower jaw being also advanced in front of those of the upper. The jaw is fixed and almost immovable, a slight downward movement being perhaps possible, so that the mouth can be somewhat further opened; but there is no upward movement or power to close the mouth. The chin is carried forwards, and therefore, when viewed in profile, the face appears to be elongated and the distance between the point of the chin and the ear increased. This produces a marked alteration in the expression of the face, which perhaps may not be fully appreciated until reduction is effected and the normal condition restored. The lips cannot be approximated, and hence there is dribbling of saliva; and deglutition and speech are impaired, the labial consonants being left unpronounced.

In the natural position of the condyle, immediately in front of the ear there is a distinct hollow, and the condyle itself can both be seen and felt in front of this, and can, unless there is much swelling, be easily recognised by the slight movement which takes place in it when the jaw is depressed. By introducing the finger into the mouth the coronoid process can be felt, just below the malar bone. The muscles of mastication are in a state of spasmodic contraction, the masseter muscle will therefore be found to stand out in bold relief on the side of the cheek, and a fulness will be observed above the zygoma, due to the same condition of the temporal muscle. Dr. R. W. Smith believes that this fulness above the zygoma is not due to spasmodic contraction of the muscle, but rather to its posterior fibres being pushed forwards by the condyle of the jaw. The pain is sometimes very great, owing no doubt to the pressure of the displaced condyle on some of the sensory filaments of the fifth nerve; at other times little or no pain is complained of.

When the dislocation is unilateral the symptoms are not so marked and the injury may be overlooked, or, what is more curious, the lesion may be diagnosed and the side on which it has occurred may be mistaken. Dr. R. W. Smith has recorded a case in which he has seen attempts made to reduce the uninjured side. This is due to the fact, that though deviation of the chin to one side is a frequent consequence of this accident, it is by no means a constant one, and therefore too much importance must not be attached to it as a symptom.

The symptoms to a very considerable extent resemble those of the bilateral dislocation, but they are not so marked. Thus the mouth is open, but not so widely open, and the jaw is to a certain extent fixed, but at the same time permits of

a certain degree of movement. There is dribbling of saliva, and speech and deglutition are to some extent interfered with. The two distinguishing signs are the hollow in front of the ear on the one side and the condyle in its natural position on the uninjured side, and, when it exists, the alteration in the direction of the axis of the jaw, and consequent deviation of the chin *away from* the injured side.

When from any cause the dislocation has been overlooked and allowed to remain unreduced, the patient will slowly regain some power of movement over his jaw. This he will generally gain to such an extent that he will be able to approximate his lips, and thus the very distressing symptom of dribbling of saliva will be removed, and his powers of articulating labial consonants will be much improved. But the inability to masticate will still remain, and the patient will therefore suffer from all the discomforts of dyspepsia or be debarred from taking solid food. The deformity of the face will also remain, though it may be improved to a certain degree.

Treatment.—In the majority of cases there is not much difficulty in reducing a recent dislocation of the lower jaw; in fact, a patient will often succeed in effecting this object for himself without surgical assistance; on the other hand, in cases in which the dislocation has been allowed to remain for some time unreduced, it is often exceedingly difficult, and sometimes impossible to effect a reduction. The simplest method in recent cases is to place the patient in an arm chair, or, what is better, a dentist chair, with the head resting against the back. The surgeon, standing in front of the patient, now introduces his thumbs, well guarded with a napkin wrapped round them, into the mouth, and presses them as far back on the lower

molar teeth as possible; at the same time the chin is grasped on either side with the fingers. Pressure is now made downwards and backwards with the thumb so as to free the condyle from the eminentia articularis. As soon as this has been done the chin is elevated, and thus a lever of the first order is constructed, of which the thumb forms the fulcrum, and reduction is by this means effected, the condyle readily gliding back into its normal position. Should this proceeding not succeed, the difficulty may possibly arise from the coronoid process being entangled in the temporal or masseter muscle, and it is advisable at first to depress the chin as much as possible, in order to free this process, before attempting reduction.

A second plan which will sometimes succeed when the first has failed, is to construct a lever of the first order by inserting wedges between the molar teeth on both sides if the dislocation is bilateral, on the injured side only if it is unilateral, and then pressing the chin directly upwards. This may be supplemented, if the pressure of the hand is not sufficient, by some mechanical aid. On one occasion I saw Mr. Pollock reduce a dislocation of four months' standing by passing an ordinary screw tourniquet round the head, the strap being placed under the point of the chin; and then by means of the screw which rested on the top of the head, tightening the strap and thus dragging the chin upwards. Sometimes in the bilateral dislocation it will be found easier to reduce one side first; but if this is done, care must be taken, in reducing the second side, that the first does not again become displaced.

In cases of difficulty the plan mentioned by Sir Astley Cooper, of using a piece of wood as a lever, may also be tried. This consists in introducing the end of a piece of wood about a foot long between the molar teeth; by raising the other end, the point resting on the

lower molars is depressed, the upper teeth acting as a fulcrum, and the jaw is by this means levered back into its place. In using this method reduction can only be effected on one side at a time.

Stromeyer has succeeded in reducing an old-standing dislocation by means of a strong pair of forceps introduced between the molar teeth with the blades closed. By separating the blades the lower jaw is depressed and the condyle disengaged from the articular eminence; the chin being now pressed backwards and upwards reduction is effected.

Nélaton, holding the views which have been before stated, with regard to the locking of the coronoid process against the malar bone, recommends that reduction should be effected by directly pressing on these processes and forcing them backwards. And in October, 1883, Mr. Golding Bird recorded a case in which he reduced a dislocation of the lower jaw by this means, which had existed for eighteen weeks, probably the longest time at which a dislocation has been successfully reduced.* M. Maisonneuve, who has made some researches on the mechanism of dislocation of the jaw, and has succeeded in effecting this lesion in more than forty instances on the dead subject, states that depression of the chin and pressure on the coronoid processes from before backwards, with the thumbs in the mouth, effected reduction constantly and with ease.†

In cases of old-standing dislocation an attempt should always be made to reduce it, if only a reasonable period has elapsed since the accident, certainly if it has not existed for a longer period than six months. For though the operation may not succeed in bringing about reduction, still very considerable benefit may be expected to be derived from the proceeding, for the

* Clin. Soc. Trans., vol. xvii., p. 32.
† Schmidt's "Jahrbuck," vol. cxix., p. 71.

efforts at reduction will rupture the adhesions and thus increase the mobility of the joint.

After the reduction is accomplished the jaw should be fixed with a four-tailed bandage so as to prevent any movement of the joint for at least a week, after which passive motion must be cautiously and regularly applied.

The lower jaw having once been dislocated, there is a great tendency to its reproduction, and in some cases the structures around the joint become so lax that the accident is constantly recurring.

CHAPTER II.

DISLOCATIONS OF THE UPPER EXTREMITY.

OF THE CLAVICLE.

1. Of the sternal end.—When we look at the want of adaptation of the two articular surfaces of the sterno-clavicular joint, and note the small saddle-shaped facet upon the upper edge of the manubrium which is intended to receive the large triangular extremity of the clavicle, and when we reflect upon the severe forces and strains to which this joint is subjected, we should be led to infer that dislocation would be of common occurrence. Such, however, is not the case. The ligaments which connect the two bones are of great strength, and to permit of dislocation must all, with the exception of the interclavicular ligament, be torn through. Accordingly we find that when a severe force is applied to the clavicle, the bone more frequently gives way, and the joint remains intact. Moreover, it must be remembered that when a force is applied to the clavicle it is generally in a

direction corresponding to the axis of the bone, which has a tendency to drive the inner end of the bone directly against the manubrium, which, acting as a fixed point, causes the bone to break from the indirect nature of the force applied to it, being compressed between two opposing forces, rather than to be luxated. For dislocation to take place the force must be applied in such a manner that it shall act laterally upon the joint, forcing the sternal end of the bone either forwards, backwards, or upwards, as the case may be.

Dislocations of the sternal end of the clavicle may take place in a direction either forwards, backwards, or upwards; that is to say, the end of the bone may be forced either in front, behind, or on to the top of the manubrium sterni.

Dislocation forwards.—This dislocation is by far the most common, and may be complete or incomplete. In the *complete* dislocation the end of the bone is driven inwards, forwards, and a little downwards, so that it lies on the anterior surface of the manubrium, a little below the level of the articular facet at its upper edge, resting on the sternal origin of the sterno-mastoid muscle (Fig. 52). To permit of this displacement all the bonds of connection between the two bones and the rhomboid ligament must be torn. The interarticular cartilage sometimes

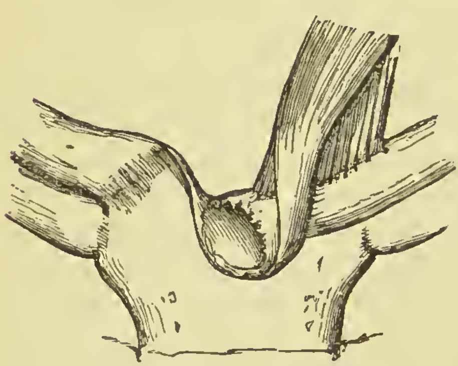


Fig. 52.—Dislocation of the Sternal end of the Clavicle forwards.

The sternal end of the clavicle has been displaced forwards, inwards, and downwards, and rests on the anterior surface of the manubrium, a little below its upper margin.

becomes separated from its attachment to the clavicle, and at others remains connected with this bone, and is carried away with it from its attachment to the sternum at its junction with the cartilage of the first rib.

Causes.—The dislocation is caused by violence applied to the acromial end of the clavicle, by which this bone is caused to rotate round an axis drawn through its centre, so that while the outer end of the bone is driven backwards, the inner end is forced forwards, and a severe strain put upon the ligaments of the articulation; these give way, and a luxation is the result. Thus, it may be caused by falls or severe blows on the front of the shoulder, or by pulling the arm, or bending the shoulder forcibly backwards. It has been said to occur from muscular action, as in throwing the shoulders violently backwards. And Hamilton has recorded a case in which it occurred during parturition. The accident may occur at all ages, but is more common in the male than the female.

Symptoms.—The injury is one which can scarcely be mistaken, the prominence of the displaced bone on the front of the sternum being characteristic, and unless the patient is very fat or great swelling has supervened, easily to be seen and felt. The only injury for which it is likely to be mistaker is fracture close to the sternal end of the bone, and Malgaigne records a case in which "the fracture was so near the sternum that it was difficult to say whether it was not a partial dislocation." As a rule, the sharp, abrupt outline of the projection, the shortening of the bone as compared with the other side, and the presence of crepitus in cases of fracture, serve to distinguish them from luxation of the sterno-clavicular joint. In dislocation, as in fracture, the shoulder is approximated to the median line, so that the distance from the point of the acromion to the middle of the sternum is less by measurement than on

the opposite side of the body. The clavicular origin of the sterno-mastoid muscle is carried downwards and inwards with the displaced bone, and presents a sharp and prominent outline, and the head is consequently inclined to the injured side. All movements of the upper extremity are attended with pain at the seat of the injury, and any attempt to rotate the scapula on the wall of the thorax occasions very considerable pain, and is resisted by the patient.

Treatment.—The reduction of this dislocation is rarely attended with much difficulty, but in consequence of the want of adaptation of the articular surfaces, and the fact that all the ligamentous bonds of union are necessarily severed before dislocation can take place, there is the greatest difficulty in maintaining the replaced bones in position, and it will consequently be found that the displacement will recur upon the slightest movement of the patient, or even from muscular action. So much is this the case that Malgaigne says that "it is difficult, and rare to cure it without deformity." Fortunately the functions of the arm do not appear to be seriously impaired by this displacement, and the patient may be comforted by the assurance, if it is found impossible to maintain the bones in correct apposition, that the arm will remain quite useful and that there will be little or no impairment of the natural movements.*

In order to reduce the dislocation, the patient should be seated on a stool, with his back to the surgeon. The operator now places his knee against the spine, between the two shoulder blades, and grasping the points of both shoulders with his hands, draws them forcibly backwards, the elbows of the patient being at the same time maintained in front of the mid-lateral line. By this means the prominence of the end of the clavicle will disappear, and the bone return to

* See a case; *Medical Times and Gazette*, vol. ii., p. 568; 1872.

its natural position. If, however, the extension is withdrawn, in many instances the displacement will at once recur. In order, therefore, to maintain it in position, the shoulders must be kept in this condition of extension ; this is to be done by placing a pad in the axilla, and applying a figure of 8 bandage firmly to the shoulders. Velpeau, believing that the recurrence of the displacement was chiefly due to muscular action, recommends that the elbow should be carried inwards and forwards, so that the hand is brought over the front of the chest and rests on the opposite shoulder, in order to relax the muscles. Whether this is so or not, there certainly appears to be less tendency to recurrence of the displacement, when the elbow is well advanced in front of the mid-lateral line. Some surgeons recommend that a pad should be placed over the joint, pressing on the end of the clavicle, and firmly fixed in this position with a figure of 8 bandage; and Nélaton has substituted for this an ordinary hernia truss, the pad being placed over the projecting bone, and the spring under the arm of the sound side. This means would appear to be scarcely efficient in maintaining the bone in position immediately after its reduction ; but is, no doubt, a useful appliance for the patient to wear when he begins to move his arm again, supporting and protecting the joint, and thus preventing any recurrence before the torn ligaments have become firmly reunited, while at the same time it allows of movement taking place in the joint.

Dislocation backwards.—This dislocation, though not of so common an occurrence as the preceding, does sometimes take place. Malgaigne has mentioned eleven examples of this injury, and other cases have at various times been recorded.* Two forms of displacement have been described : one in

* For several cases see *Edinburgh Journal of Medical Science* for October, 1841.

which the end of the clavicle is displaced backwards and downwards, and the other when it is thrown backwards and upwards. In the former, which appears to be the more common accident of the two, the end of the bone lies behind the upper part of the sternum, below its normal level, buried in the connective tissue behind the origins of the sterno-hyoid and sterno-thyroid muscles. In the other form of dislocation, backwards and upwards, the end of the bone is displaced backwards, and is raised somewhat above its natural position, probably by the action of the sterno-mastoid muscle. The head of the clavicle can be felt in this situation, one-half or three-quarters of an inch above the level of the bone on the opposite side.

Causes.—The injury may be caused either by direct or indirect violence, the latter being the more common of the two.* When produced by indirect force, the violence is applied to the shoulder, driving it inwards and forwards, as from a severe fall, or from pressure on the shoulder, as in a case where the lesion was produced by the shoulder being violently pressed against a wall by a carriage.† When caused by direct violence, the force is applied to the inner end of the clavicle, driving it directly backwards ; it has thus been produced by the kick of a horse, and by the passage of the wheel of a carriage over the chest. Two or three cases are recorded where the accident has occurred during wrestling ; but here it is very difficult to say whether there was direct or indirect violence, since, under these circumstances, it is often impossible to obtain any exact history of the position in which the combatants were at the moment of the accident.

* Mr. Poland states that of twenty cases which he has collected, seven were from direct and thirteen from indirect violence (*Lancet*, vol. ii., p. 104 ; 1884).

† *American Journal of Medical Science*, vol. xxix., p. 229.

Here, as in the preceding dislocation, there must be complete rupture of all the ligaments connecting the two bones together, as well as the rhomboid ligament. Erichsen records a case in which this latter ligament was not torn, but had carried away the cartilage of the first rib in the direction of the displaced clavicle.

Symptoms.—There is pain in the part and inability to use the extremity. The head, which is inclined to one side, is more or less fixed, and the movements of the neck impaired. The point of the shoulder is thrown forwards, and is approximated to the median line of the body. There is a well-marked depression at the sterno-clavicular articulation, due to the absence of the head of the bone from its socket. And there is either a complete or partial disappearance of the end of the clavicle behind the sternum, or else this portion of bone may be felt on the front of the neck, on a somewhat higher level than the corresponding articulation. Besides these, special symptoms may arise from pressure on neighbouring structures. The displaced bone may press upon the trachea, causing dyspnœa, or it may push this tube over to the opposite side, and, pressing on the œsophagus, cause dysphagia. This is what generally appears to take place when the bone is displaced backwards and upwards. When it is displaced backwards and downwards both tubes are pressed upon, and there is difficulty both in respiration and deglutition. Or the large vessels in this situation may be subjected to pressure; the subclavian artery may be so compressed as to arrest the pulse at the wrist, or the brachio-cephalic vein may be so occluded as to give rise to congestion of the head, and even to a condition of semi-coma.*

Treatment.—In order that reduction may be effected, all that is usually necessary is to draw the

* *See* a case; Schmidt's "Jahrbuch," vol. cvi., No. 5, p. 200.

shoulders backwards. This may be generally accomplished by placing the knee against the spine, between the two scapulæ, and dragging the two shoulders backwards. If there is any difficulty, as there sometimes may be when the bone is displaced downwards as well as backwards, this plan may be supplemented by placing a large firm pad in the axilla and pressing the elbow well into the side, at the same time that the shoulders are bent backwards. After reduction there is great difficulty in retaining the bone in position. To fulfil this object, a large pad should be placed over the spine, and a figure of 8 bandage tightly applied over the points of the shoulders. Or a splint may be placed across the shoulders, over the pad, and firmly bandaged in such a manner that the shoulders are drawn backwards to the splint. In extreme cases the symptoms of dysphagia or dyspnœa may be so urgent as to necessitate the removal of the end of the bone.

Dislocation upwards.—This form of luxation is of very rare occurrence. Dr. R. W. Smith, writing in 1872, says, "The archives of surgical science contain only seven examples of the injury under consideration." And to these he has added an eighth case.

The dislocation somewhat resembles one form of the preceding, where the end of the clavicle was displaced backwards and upwards, only that in this form the displacement is more in an upward direction and less backwards; so that the head of the bone rests on the upper border of the sternum, between the sterno-mastoid and sterno-hyoid muscles (Fig. 53). That in some of the cases, at all events, there has been some displacement backwards, is evident from the fact that severe dyspnœa from pressure on the trachea has been complained of.

In Dr. Smith's case, in which he had an opportunity of examining the parts after death, "the end of the left clavicle was seen lying above the sternum, beyond

the centre of which it had so far passed as to be in contact with the inner edge of the right sterno-mastoid muscle. The sternal portion of its own muscle, crossed in front of it at some distance external to its articular surface, was arched forward and in a state of tension, while the clavicular portion was relaxed." *

Causes.—This dislocation can only be produced by indirect force applied to the shoulder. This force, as Dr. Smith has pointed out, must act in a very unusual direction, carrying the shoulder downwards and inwards, and probably also backwards, and hence the variety of the accident.

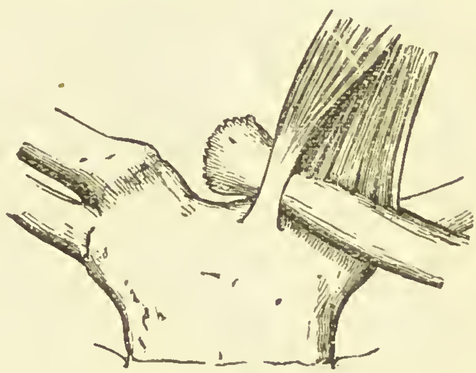


Fig. 53.—Dislocation of the Sternal end of the Clavicle upwards.

The sternal end of the clavicle has been displaced upwards and slightly backwards, and rests on the upper border of the sternum, internal to the sternal origin of the sterno-mastoid muscle.

Symptoms.—As in the other two forms of dislocation of this joint, the shoulder is drawn inwards to the mesial line, and there is impaired movement in the extremity. The sternal end of the clavicle forms a prominent swelling in front of the trachea. The axis of the clavicle is altered and is directed forwards and upwards, and there is a considerable interspace or hollow between it and the first rib. The sternal origin of the sterno-mastoid presents a well-marked arched outline on the front of the neck. In some cases there is dyspnœa, increased if the patient sits up or leans forward; in other cases no dyspnœa is complained of.

Treatment.—In order to effect reduction it is necessary to draw the shoulder outwards, at the same

* *Dublin Quarterly Journal*, vol. liv., p. 452.

time pressing the head of the bone downwards into its socket. This is best done by placing a large and hard pad in the axilla to act as a fulcrum, and then pressing the elbow into the side of the chest; when sufficient extension has been made, an endeavour should be made by direct pressure on the head of the bone to force it downwards. By this means reduction can usually be readily effected. Recorded cases appear, however, to prove that it is next to impossible to retain the bone in its place. The best plan appears to be to bind the arm to the side with a pad in the axilla, the bandage being arranged in such a manner that it will raise the shoulder by carrying it round the point of the elbow and over the opposite shoulder. At the same time the sternal end of the clavicle must be pressed downwards by a pad and bandage. The presence of a certain amount of permanent displacement does not appear to be greatly prejudicial either to the movements or strength of the arm.

2. **Dislocation of the acromial end of the clavicle.**—This injury ought more correctly to be described as dislocation of the acromion of the scapula, since in speaking of a dislocation we allude, as a rule, to the displacement of the more distal bone. (*See* page 310.) But as the above appellation is the one in common use, it has seemed better to retain it, rather than introduce a new term which might lead to confusion.

When a dislocation takes place at the acromio-clavicular joint, on account of the peculiar relation and inclination which the joint surfaces have to one another, it most usually occurs in one direction; that is to say, the clavicle is displaced upwards on to the acromion process of the scapula* (Fig. 54). Nevertheless, the reverse may happen and the acromion may be forced above the clavicle.

* *See* Humphrey on the "Skeleton," Plate xxviii., Fig. 4.

Although luxation at this joint is a more common accident than at the sterno-clavicular articulation, still it is by no means an injury of frequent occurrence. In spite of the slight security afforded by the shape of its articular surfaces, the strength, mainly derived from the ligaments, is sufficient to withstand the injuries to which it is exposed. The strong conoid and trapezoid ligaments check the movements of the joint and prevent the scapula being driven too far by blows upon the shoulder. These ligaments are, therefore, the mainstay of the articulation, and on them it depends mainly for its strength.

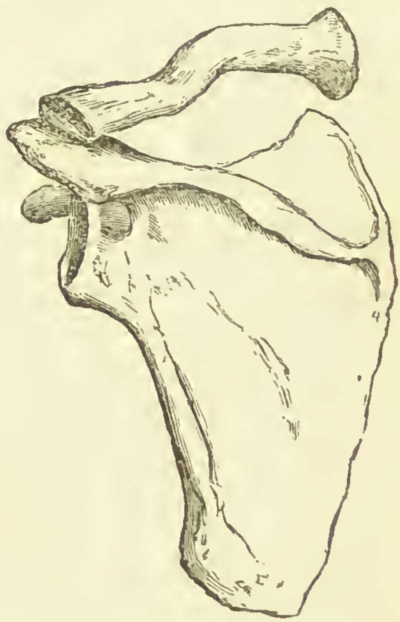


Fig. 54.—Dislocation of the Acromial end of the Clavicle.

The acromial end of the clavicle has been displaced upwards and rests on the acromion process of the scapula.

Causes. — Dislocation at the acromio-clavicular joint is almost invariably produced by a direct blow on the scapula. Thus it has been caused by a kick or severe blow on the outer part of the shoulder, especially if the blow or kick has been given from behind, so as to drive the point of the shoulder forwards. Or it has been caused by falls from a height on to the back and outer part of the shoulder, or even by the patient having been violently thrown and this part of the body coming in contact with the ground, as in the game of football.

Symptoms.—The signs of this dislocation are unmistakable. In the usual form, the prominence

formed by the displaced outer end of the clavicle upon the top of the upper surface of the acromion process of the scapula cannot well be mistaken for anything else. In addition to this, the movements of the arm are impeded, and the patient is unable to raise the extremity upwards over his head; the shoulder is depressed and approximated to the mesial line of the body. The arm appears to be lengthened and hangs helplessly by the side. The clavicular portion of the trapezius muscle stands out in bold relief, and the head is sometimes inclined to the injured side.

Treatment.—The treatment is by no means satisfactory; for, though the dislocation can usually be reduced with great facility, it is well-nigh impossible, on account of the inclination of the joint surfaces and the constant action of the trapezius muscle, to keep the bone in position. Very little inconvenience appears to result, however, from a want of *complete* coaptation, and beyond the presence of a somewhat ugly deformity, no evil is complained of, and the utility of the limb is but little impaired. But, on the other hand, when the dislocation is allowed to remain completely unreduced, and the clavicle rides on the top of the acromion, considerable interference with the movements of the arm is the result, the patient being unable to raise a weight above the level of the shoulders; and thus, especially in the case of a labouring man, being seriously and permanently maimed.

In order to effect reduction, all that is generally necessary is to drag the point of the shoulders well backwards, and at the same time press the displaced end of the clavicle downwards into position. Sometimes it is of advantage to carry the shoulder outwards by placing a pad in the axilla and bringing the elbow down to the side; sometimes, by raising the shoulder, reduction will be more easily

effected. By whatever means the end of the bone is restored to its normal position, it will generally be found that immediately on relaxing the extending force the displacement will return, and therefore considerable care will have to be expended in adjusting the bandages or apparatus, so as to prevent this accident taking place; and even with the utmost care the surgeon must be prepared to find that a recurrence of the displacement has taken place, and will do well to caution his patient as to its probabilities. The great disposition which the bone has to slip out again has led to many suggestions and different plans of treatment, none of which, however, have completely fulfilled the purposes for which they were intended. Of all the plans of treatment, the one which seems to hold out the greatest prospect of success is, to keep the outer end of the clavicle depressed, and, at the same time, the scapula raised by means of a pad placed over the acromial end of the clavicle, and firmly strapped in this position by a broad webbing carried over it and round the point of the elbow, and fixed by a buckle. In addition to this, the arm must be bandaged to the chest with a rib roller, in order to restrain, as much as possible, the movements of the scapula. The main objection to this plan of treatment is, the inability of the skin over the clavicle, and perhaps, though in a less degree, over the point of the elbow, to bear the requisite amount of pressure, and great watchfulness will be required on the part of the surgeon lest serious damage should be done to this structure.

The principal cause of the constant recurrence of the displacement is the action of the trapezius muscle, and it has been suggested that by inclining the head to the affected side, and at the same time elevating the shoulder, this action would be, to some extent at all events, rendered inert. No doubt the suggestion

is a useful one, though at the same time it may be surmised that very few patients would be induced for long to maintain such an irksome and uncomfortable position.

Dislocation of the acromial end of the clavicle downwards.—Of this form of dislocation there are two varieties. One where the outer end of the clavicle is displaced beneath the acromion process and rests on the capsule of the shoulder joint; in the other, which has lately been described, the end of the clavicle is said to be displaced to such an extent that it lies beneath the coracoid process. Further records of cases, and especially an examination of a suspected case after death, require to be obtained before the exact nature of this remarkable lesion can be established.

The cases belonging to the first class, where the end of the clavicle has been depressed beneath the acromion, are very rare, only three authentic cases having been placed on record. They all appear to have been produced in the same way, by blows from above on the outer end of the clavicle. The symptoms are well marked; the projection of the acromion and coracoid processes, the inclination of the clavicle, and the marked depression in the situation where its outer end ought to be, are sufficient to denote the nature of the lesion. Reduction is to be effected by drawing the shoulders backwards, and in the cases recorded there does not appear to have been any great difficulty in maintaining the parts in position.

Simultaneous dislocation of both ends of the clavicle.—Cases have occasionally been recorded in which the clavicle has been dislocated at both ends, that is to say, at both the sterno-clavicular and acromio-clavicular joints, at the same time and by the same accident. At least eight of these cases have been recorded, and they are of interest, more as

curiosities in the literature of the subject than from any peculiar features which they present. Cases have been recorded by Morel-Lavillée,* Richeraud,† North, of Brooklyn, N.Y.,‡ Gerdy,§ Hutchinson,‖ Stanley Haynes,¶ Lund,** and Col, of Bourg d'Oisans.††

Dislocation of the Humerus.

The shoulder joint, on account of the free movement which it enjoys, is peculiarly liable to dislocation. To allow of this free range of movement, the anatomical construction of the joint is such as to render it very insecure, and particularly predisposed to luxation. We have a large globular head articulating with a shallow glenoid cavity, and the two surfaces connected together by a loose and thin capsular ligament. These circumstances, combined with the exposed situation of the articulation and the length of the arm, cause this joint to be more frequently dislocated than any other in the body. In fact, it is stated that displacement of this articulation occurs almost as frequently as it does in all the other joints together.

The accident is one of adult life, rarely occurring before puberty; but is occasionally met with in persons of advanced age.

The different dislocations of the shoulder are usually described as four in number. To these, however, must be added a fifth, of which three cases have been recorded. They may be tabulated as follows:

1. Where the head of the bone is thrown forwards, inwards, and slightly downwards; the *subcoracoid.*

* *Gazette des Hôpitaux*, No. 33; 1859.
† *British and Foreign Med.-Chir. Review*, vol. i., p. 262; 1873.
‡ *New York Med. Record*, April 16th, 1866.
§ *British Med. Journal*, vol. i., p. 106; 1872.
‖ *Lancet*, vol. ii., p. 711; 1871.
¶ *British Med. Journal*, January 27th, 1872.
** Ibid., vol. i., p. 106; 1874.
†† *Gazette des Hôpitaux*, No. 112; 1872.

2. Where the head of the bone is thrown downwards and slightly forwards and inwards; the *subglenoid.*

3. Where the head of the bone is thrown backwards, inwards, and slightly downwards; the *subspinous.*

4. Where the head of the bone is thrown forwards, inwards, and upwards; the *subclavicular.*

5. Where the head of the bone is thrown upwards and forwards; the *supracoracoid.*

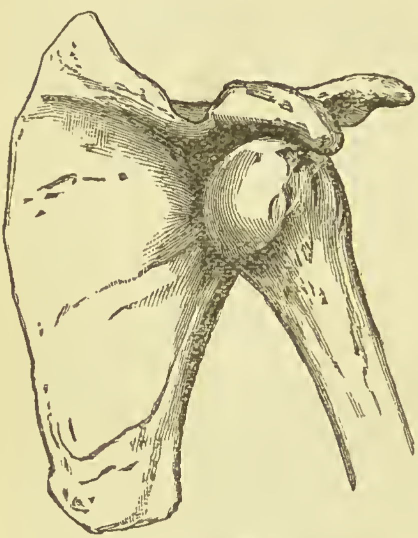


Fig. 55.—Subcoracoid Dislocation of the Humerus.

The head of the humerus has been thrown forwards, inwards, and slightly downwards, so that the anatomical neck of the bone rests on the anterior edge of the glenoid cavity, immediately below the coracoid process.

1. **Subcoracoid.**—This is by far the most common form of dislocation of the shoulder joint. Mr. Flower has stated that of forty-one specimens of this injury which he had examined in the museums of the London hospitals, no less a number than thirty-one were of the subcoracoid variety.*

In this dislocation the head of the bone is thrown inwards, forwards, and slightly downwards, so that the anatomical neck of the humerus rests on the anterior edge of the glenoid cavity, immediately below the coracoid process of the scapula (Fig. 55). The principal anatomical difference between this dislocation and the subglenoid one, with which it has been so frequently mistaken, is in the relative position of the head of the

* Path. Soc. Trans., vol. xii.

humerus to the subscapularis muscle. In this luxation the head of the bone lies *above* the tendon of the subscapularis muscle, which is frequently torn; when this is not the case, the fibres of the muscle are pushed downwards, so as to form a curve, embracing the neck of the bone, and thus constituting an important impediment to reduction. In the subglenoid dislocation, on the other hand, the head of the humerus rests on the inferior costa of the scapula, *beneath* the tendon of this muscle, and between it and the teres minor. In the subcoracoid dislocation the head of the bone occasionally protrudes through the hole which exists in the capsular ligament; generally, however, the anterior part of this membrane is torn to allow of the displacement of the bone. Malgaigne describes two distinct varieties of this luxation, which he describes respectively as the *subcoracoid* and the *intracoracoid.* The difference appears to be simply due to the amount of rotation of the humerus. If the external rotators attached to the greater tuberosity of the humerus remain intact, there is naturally considerable rotation of the humerus outwards, and Malgaigne's "subcoracoid" displacement is produced; if on the other hand, these muscles have been lacerated, or perchance the greater tuberosity has been torn off, the humerus is turned considerably more inwards, and his "intracoracoid" displacement is the result. In both cases, however, the essential feature of the displacement is the same, namely, that the anatomical neck of the humerus rests on the anterior margin of the glenoid cavity. Subcoracoid dislocation may be produced either by direct or indirect violence. That is to say, it may be caused either by a direct blow or fall on the shoulder, inflicted in such a manner as to drive the upper end of the humerus forwards and inwards, or by indirect violence applied to the joint by falls upon the elbow or hand when extended from the body.

2. **Subglenoid.**—This dislocation is sometimes termed *axillary*, the head of the bone being displaced downwards into the axilla, and, at the same time, a little forwards and inwards (Fig. 56). It rests upon the inner border of the inferior costa of the scapula, between the subscapularis above, the long head of the triceps behind, and the teres muscles below (Fig. 57). These structures are often considerably lacerated and bruised. It is caused by falls on the elbow or palm of the hand, when the arm is raised from the side; the head of the humerus is thus driven against the lower part of the capsular ligament; this membrane is torn, and the head of the bone driven through the rent. This dislocation may also be produced by muscular action, by the contraction of the latissimus dorsi and teres major, when the arm is raised to a right angle with the trunk, and the head of the humerus approaches the lower margin of the glenoid cavity. Thus, Monro mentions a case of an actress who dislocated her shoulder in the exercise of her profession; and Humphrey mentions an instance of a gentleman who sustained the same injury while swimming. In this form of dislocation the capsular ligament is always torn,

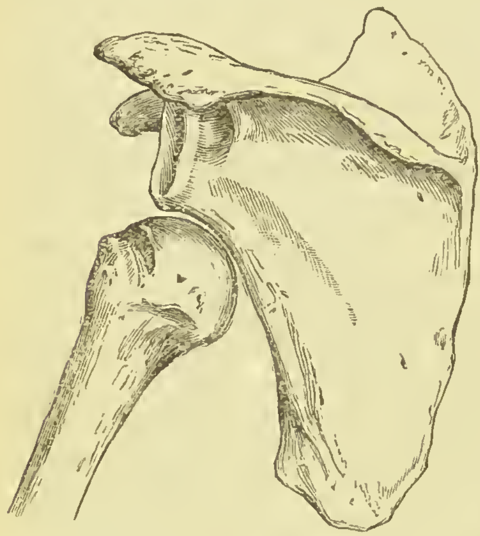


Fig. 56.—Subglenoid Dislocation of the Humerus.

The head of the humerus has been displaced downwards into the axilla, and at the same time a little forwards and inwards, so that it rests on the inner border of the inferior costa of the scapula.

and the subscapularis muscle generally so. It is this muscle which appears to suffer the greatest injury, though in some cases the remaining capsular muscles, those inserted into the greater tuberosity of the humerus especially, have also sustained damage. Occasionally it has been found that the tuberosity itself has been separated from the bone, instead of the muscles becoming lacerated. Sir Astley Cooper believed that the greatest impediment to reduction was the supraspinatus and deltoid muscles, but in other instances this does not appear to have been the case. In a specimen dissected by Sir P. Crampton, where the supraspinatus was torn, the impediment to reduction appeared to be caused by the closing of the biceps and triceps behind the head of the bone. So that we must agree with Adams when he says: "That in apparently similar dislocations of the humerus there may be very different kinds as well as degrees of lesion, and, consequently, very different causes of resistance to reduction."

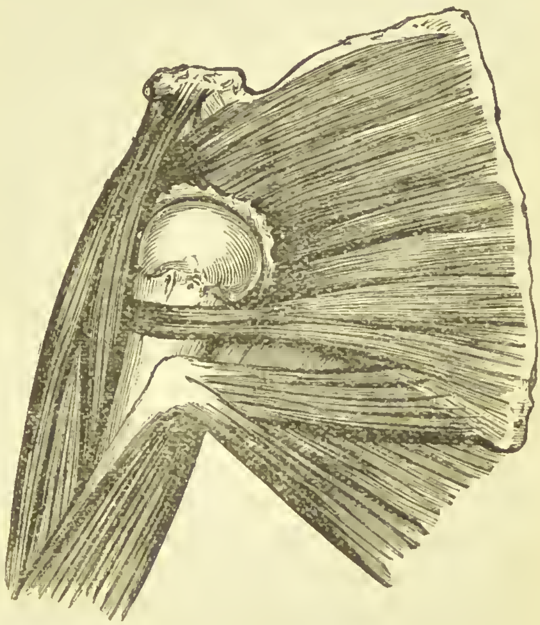


Fig. 57.—Recent case of Subglenoid Dislocation of the Humerus.

The head of the bone, in escaping from its socket, has burst through the lower part of the subscapularis, some of the fibres of which closely embrace the neck of the bone. (After Sir P. Crampton.)

3. **Subspinous.**—The dislocation backwards is comparatively rare. The only case in which I have had an opportunity of seeing this form of dislocation was in a man who was crossing the lines of a railway with his hands in his pockets. His toe caught in one of the rails and he fell forwards, striking the point of his shoulder in front. This appears to be the way in which these dislocations are sometimes produced, by blows on the front of the shoulder or on the elbow when the arm is carried forwards or stretched across the chest.

There seems to be, however, very good ground for believing that many instances of this form of dislocation, and also of the subcoracoid variety, are *primarily* displacements downwards into the axilla, and that the subsequent alteration in the position of the head of the bone to beneath the coracoid or spinous processes is due to muscular contraction or to the direction of the violence. Most dislocations are due to violence applied to the limb when the arm is away from the side. When the limb is in this position the head of the humerus projects beyond the lowest point of the glenoid cavity, and stretches the inferior part of the capsular ligament. Any force applied to the limb easily tears this ligament while in this condition of tension, and the head of the bone is driven through the rent into the axilla, producing the subglenoid form of dislocation. But, immediately, the violent contraction of the muscles in this region, such as the deltoid, coraco-brachialis, and biceps, pull the bone upwards, either beneath the coracoid process or spine of the scapula. This hypothesis would explain the great frequency of the subcoracoid displacement, for we have not only the influence of the muscles enumerated above tending to draw the head of the bone upwards, but we have also the powerful action of the great pectoral and other muscles drawing it forwards

and inwards. The subspinous dislocation can only, therefore, be produced when the direction of the violence has been applied markedly to the front of the head of the bone.

In the subspinous dislocation the head of the bone is driven backwards and downwards, and rests on the back of the scapula, in the infraspinatus fossa, immediately beneath the spine, and between the infraspinatus and teres minor muscles (Fig. 58). In this form of dislocation, as in the others, the subscapularis is the muscle which appears to suffer most.

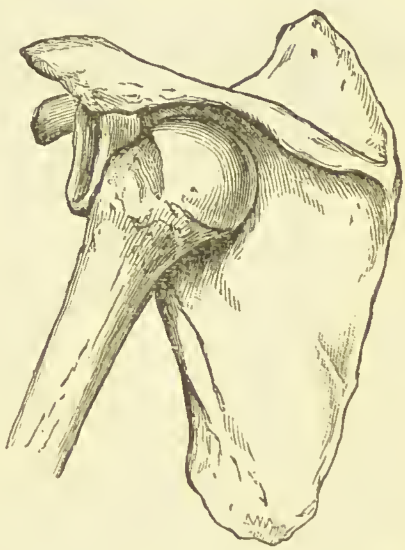


Fig. 58.—Subspinous Dislocation of the Humerus.

The head of the humerus has been displaced backwards and downwards, and rests on the back of the scapula, in the infraspinatus fossa, immediately beneath the spine.

Malgaigne has described two forms of dislocation backwards, one where the head of the bone rests beneath the spine of the scapula (subspinous), the other where it rests beneath the acromion process (subacromial). The latter appears to be only a less complete form of luxation, and it seems unnecessary to class them as two distinct varieties.

4. **Subclavicular.**—The subclavicular form of dislocation is very rare, and would appear to be merely an exaggerated form of the subcoracoid. It is caused by the same form of violence that sometimes produces the subcoracoid variety; that is to say, by the head of the humerus being forcibly driven against the anterior part of the capsular ligament, which gives

way. The displacement, however, is greater, the humerus is driven farther inwards and forwards, and rests on the front of the chest, immediately below the clavicle, and underneath the great pectoral muscle (Fig. 59). In one case described by Malgaigne, the head of the bone was forced between the pectoralis major and deltoid muscle, and was covered only by integument and fascia. In consequence of the great displacement which takes place in these cases, no doubt requiring considerable force to produce it, we generally find that there is great laceration of the muscles attached to the tuberosities of the humerus. In cases in which a dissection of the part has been made, the supraspinatus, infraspinatus, teres minor and subscapularis have all been found to be torn or separated from their attachment to the bone.

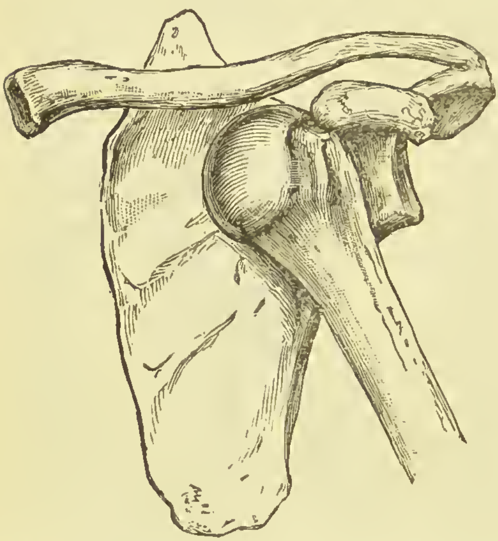


Fig. 59.—Subclavicular Dislocation of the Humerus.

The head of the humerus has been driven forwards and inwards, and is situated immediately beneath the middle third of the clavicle.

5. **Supracoracoid.**—Of this form of accident only three cases have been recorded. In the first, mentioned by Malgaigne, the head of the bone rested between the coracoid and acromion processes, upon the coraco-acromial ligament, and projected beneath the deltoid. A second case, recorded by Holmes,* occurred in consequence of a fall, from a height of about thirty

* Med.-Chir. Trans., vol. xli., p. 447.

feet, on to the elbow. The coracoid process was fractured, and the head of the humerus, resting partly upon it, was also in contact with the anterior border of the clavicle at that part of the bone which lies between the points of attachment of the pectoralis major and deltoid muscles (Fig. 60). In the same paper Mr. Holmes details the symptoms of a third and apparently similar case, as having fallen under the observation of Sir Prescott Hewett.

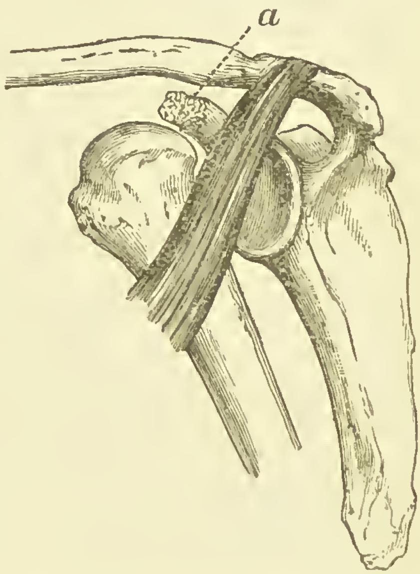


Fig. 60.—Dislocation of the Head of the Humerus upwards.

The head of the humerus has been driven directly upwards, and rests above the level of the glenoid cavity, against the coracoid process (*a*) which was fractured. (From a preparation in the museum of St. George's Hospital, series i., No. 107.)

Symptoms.—In three out of the four common dislocations * of the shoulder joint the head of the bone is driven downwards; that is to say, it rests in its new situation at a lower level than it does when in its normal position, and, therefore, we get lengthening of the limb. The displacement downwards is very great in the subglenoid dislocation, and so the lengthening is considerable; less in the subspinous and least in the subcoracoid. In the subclavicular the head of the humerus rests on a higher level

* In this analysis of the signs of dislocation of the humerus, all consideration of the supracoracoid form is disregarded, as an exceedingly rare and scarcely recognised variety. A word or two will be presently said on the special signs of this form of dislocation.

than when in its natural position in the glenoid cavity, and therefore the limb is shortened.

The main symptoms of dislocation of the shoulder, common to all forms, are six in number: (1) pain about the part; (2) flattening of the shoulder; (3) apparent prominence of the acromion process; (4) a depression beneath this process; (5) rigidity or impaired mobility about the joint; (6) the presence of the head of the bone in a new situation.

Upon being called to a case, our attention is at once drawn to the injured part by (1) the pain complained of by the patient, and at a glance we notice a general (2) flattening of the shoulder, and on a closer scrutiny we see that (3) the acromion process appears to project considerably, and to be much more prominent than on the other side, and that (4) beneath it there is a remarkable hollow, where there ought to be a roundness or fulness (Fig. 29 B, page 170.). So far our symptoms point to a serious injury about the shoulder joint, which may be either dislocation or a fracture in the neighbourhood of the articulation. By further examination we find, that on attempting to move the articular surfaces on each other, there is (5) impaired mobility; that is, that the bony surfaces do not glide on each other easily, and any attempt to move them causes increased pain; this is especially noticeable upon any effort being made to approximate the elbow to the wall of the chest. In fact, Dr. Dugas has pointed out that "if the fingers of the injured limb can be placed by the patient, or by the surgeon, upon the sound shoulder, while the elbow touches the thorax (a condition which obtains in the normal condition of the joint), there can be no dislocation; but if this cannot be done there must be one, for no other injury than a dislocation can induce this physical impossibility." * A careful

* *Southern Medical and Surgical Journal*, May, 1858.

examination also generally enables us (6) to feel the head of the bone in its new situation, and thus our diagnosis of dislocation is established.

The next point to ascertain is the particular variety of displacement which has taken place, and this may be mainly done by attention to three signs: (1) the direction of the axis of the limb; (2) the presence of lengthening or shortening and its amount; (3) the situation in which the head of the bone can be felt and the ease with which it can be perceived. This last sign, though often of great value, is sometimes obscured by the swelling which has taken place.

These various signs may be tabulated as follows:

	Direction of axis of limb.	Alteration in length of limb.	Presence of the head of the bone in a new situation.
1. Subcoracoid.	The elbow is carried backwards and slightly away from the side.	Very slight lengthening.	The head of the bone cannot easily be felt; if it can, it is found at the upper and inner part of the axilla.
2. Subglenoid.	The elbow is carried away from the trunk and slightly backwards.	Very considerable lengthening.	The head of the bone can be easily felt in the axilla.
3. Subspinous.	The elbow is raised from the side and carried forwards.	Lengthening intermediate in degree between the subglenoid and the subcoracoid.	The head of the bone can be felt and grasped beneath the spine of the scapula.
4. Subclavicular.	The elbow is carried outwards and backwards.	Shortening.	The head of the bone can be readily *seen* and felt beneath the clavicle.

So that the elbow is carried principally backwards in the subcoracoid, outwards in the subglenoid, forwards in the subspinous, and backwards and outwards in the subclavicular. There is very considerable lengthening in the subglenoid ; less in the subspinous ; least in the subcoracoid, and there is shortening in the subclavicular. The head of the bone is most distinct in the subclavicular variety ; less so, but still easily to be made out, in the subspinous and subglenoid ; indistinct and often difficult to detect in the subcoracoid.

Such, then, are the general symptoms by which these various dislocations may be diagnosed one from another. And, as a rule, by attention to these points there is generally no great difficulty in arriving at a correct conclusion. It must be confessed, however, that clearly as certain points may be laid down on paper as regards the differential diagnosis between these different forms of dislocation, in actual practice there will often be found to be discrepancies which it will be difficult to reconcile. It is necessary, therefore, to say something further about each particular dislocation and the various abnormalities or accidental features which it may present.

Subcoracoid.—As regards the position of the elbow various differences of opinion exist. By some it is described as projecting from the side ; by others as touching it. By some it is described as being sometimes behind and sometimes in front of the body. Mr. Flower, in his analysis of twenty-seven cases, states that the elbow was directed backwards in eight, forwards in nine, and in the middle line, or in a position not recorded, in ten. * The humerus is generally rotated outwards, but may be rotated inwards. But in whatever position the elbow may be, there is always an alteration in the direction of

* Med.-Chir. Trans., June 12, 1860.

the axis of the bone, and on tracing the shaft upwards towards the head, it is evidently directed inwards, away from its normal direction. Much difference of opinion also seems to prevail as to whether the arm is lengthened or shortened as a result of the subcoracoid dislocation. Probably the amount of alteration as regards the length is in most cases very slight.

In thin subjects the head of the humerus can be felt, fairly easily, through the great pectoral muscle; but in stout people, or in those with large muscular development, it is by no means easy, though even in these individuals there is generally some greater fulness of the anterior fold of the axilla than natural. In these persons it is sometimes possible to feel the head of the bone from the axilla. By placing the fingers deeply in this space, under the anterior fold; the arm being raised from the side the globular head can be detected occupying the upper and anterior part of the space. It sometimes happens in these cases that the cords of the brachial plexus may be pressed upon or injured, producing severe pain extending down the arm as far as the fingers, and often accompanied by a sensation of numbness, and occasionally even more serious symptoms. Dr. Bernhard has related two cases in which dislocation of the head of the humerus was followed by paralysis. In one of the cases reduction was effected eight days after the injury; in the other the dislocation was reduced on the day of its occurrence.* Occasionally, also, the axillary vein may be pressed upon, producing œdema, or the axillary vessels may be ruptured.†

2. **Subglenoid.**—It has been before stated that many dislocations of the preceding and of the subspinous variety are primarily subglenoid, and that

* *Berliner Klin. Wochenschr.*, No. 5, 1871.
† *Brit. Med. Journ.*, vol. ii., p. 634; 1863.

the head of the bone having been first displaced downwards into the axilla, is then drawn upwards by muscular action till its progress is arrested by the coracoid or spinous processes, as the case may be. The reason why this does not take place in every case, and that sometimes the head of the bone remains in its primary position beneath the glenoid cavity, appears to be on account of the position of the laceration in the capsular ligament, the rent being at its inferior part and not implicating the anterior surface; and that this, and no doubt also the soft structures, mechanically interfere with the tendency of the muscles to draw the head of the bone upwards.

There is no question that this form of dislocation is very much more uncommon than was formerly supposed, when it was stated to be the most common variety of dislocation of the shoulder joint. * This error was no doubt due, in a great measure, to the similarity in the symptoms which exist between the subcoracoid and subglenoid forms of luxation, though in the latter these signs are more pronounced and well-marked than in the former. Thus there is more apparent projection of the acromion process and more flattening beneath it. The head of the bone is much more distinctly to be felt in the axilla, and there is decided lengthening of the arm. The elbow is thrown much more decidedly away from the trunk, and cannot be approximated, at all events without causing great pain, to the side of the chest. There is not the same tendency on the part of the elbow to be inclined backwards, as is usually observed in the subcoracoid variety, though even in this form there is a tendency for the elbow to be directed backwards rather than forwards. The main points of distinction,

* Flower states that out of seventy-two cases only eight belonged to this variety; Med.-Chir. Trans., June 12, 1860.

however, between the two forms of dislocation are to be found in the appearance of the anterior fold of the axilla and in the relative position of the head of the bone to the coracoid process. In the subcoracoid dislocation it was remarked that there was a fulness of the anterior fold of the axilla; in the subglenoid there is, on the other hand, a depression due to the drawing down of the pectoralis major at its attachment to the humerus. Again, in the subcoracoid displacement the head of the bone, if it can be made out, will be felt to be in close apposition to the coracoid process, whereas in the subglenoid variety a distinct interval, sometimes as much as two inches, may be felt between these two structures.

Mr. Hulke has recorded two cases of a very rare form of subglenoid dislocation which came under his notice in King's College Hospital, and in which the arm was abducted and raised. To these he has given the name of "luxatio erecta." * A similar case is recorded by Dr. Cleland, of Galway. † The patient was lame and used crutches; and Cleland supposed that one of the crutches, having slipped, acted as a fulcrum in such a way as to cause the weight of the body in falling to overcome the tendency of the latissimus dorsi and pectoralis major muscles to draw the arm to the side. ‡

In some cases of subglenoid dislocation the axillary vessels have been so much displaced and compressed by the head of the bone as entirely to arrest the circulation through them. Erichsen relates a case in which this was remarkably illustrated. The patient had a dislocation downwards of the head of the humerus, and also a severe lacerated wound of the fore-arm, dividing the radial and ulnar arteries. So

* "System of Surgery," vol. i., p. 978.
† *Brit. Med. Journ.*, vol. i., p. 140; 1868.
‡ *See* also Schmidt, vol. cvi., No. 5, p. 201.

long as the dislocation remained unreduced, no hæmorrhage took place; but when the head of the bone was replaced the injured arteries bled freely. The brachial plexus may also, in these cases, be injured, and the functions of the nerves interfered with. It is in the dislocation downwards that the circumflex nerve is most liable to be injured; winding round the articulation, it is sometimes compressed by the head of the humerus, when displaced into the axilla, to such an extent as completely to arrest its functions and produce paralysis of the deltoid muscle and loss of sensation in the skin over the outer surface of the shoulder.

Subspinous.—In this rare form of dislocation, as before stated, the position of the head of the bone may vary; in the more common variety it is found resting on the posterior edge of the glenoid cavity (the "subacromial" dislocation of Malgaigne); in rarer instances it is placed on the dorsum of the scapula, in the infraspinatus fossa, immediately below the spine (the true "subspinous" dislocation). The only difference between the two is in the extent of the displacement, which appears to depend upon the degree of laceration, and the distinction, therefore, appears to be superfluous. The symptoms, nevertheless, vary with the amount of the displacement, and are much more marked in the subspinous than in the subacromial variety. In both the axis of the bone is directed backwards, so that the elbow is advanced in front of the body, but can be approximated to the side of the chest. The bone is at the same time rotated inwards, so that the fore-arm is thrown across the front of the body. There is some lengthening. The head of the bone forms a considerable prominence, especially when it rests on the dorsum of the scapula, when it can be easily grasped, and forms a characteristic feature in this dislocation. And in addition

to this there is a marked depression beneath the coracoid process.

Subclavicular. — This form of dislocation would appear to be an increased degree of the sub-coracoid variety; the head of the bone, when raised by muscular action, instead of being lodged against the coracoid process, is drawn upwards to the inner side of this process, against the under surface of the clavicle, where it rests upon the second and third ribs beneath the pectoralis major muscle. In these cases, on account of the greater amount of displacement of the head of the bone, the acromion is more pointed and prominent, and there is a greater amount of flattening beneath it than in any other variety of dislocation of this joint. The most prominent sign, however, is the presence of the head of the bone in its new situation, where it can not only be easily felt, but also distinctly *seen*, forming a rounded, circumscribed elevation immediately beneath the clavicle. The elbow is, as a rule, thrown outwards and backwards, though in some cases, according to Malgaigne, the outward displacement is only very slight, the arm being pressed against the chest and the elbow only slightly removed from the side.

There is in these cases always considerable shortening, and the shaft of the bone can be felt in the axilla, the axis of the bone being altered and directed towards the head of the patient.

Supracoracoid.—This rare form of dislocation, of which, as far as I am aware, only three cases have been recorded, appears to be caused by direct violence applied in an upward direction, and, according to Mr. Holmes, can only occur after fracture of the coracoid or acromion process, usually the former.* It is therefore a mixed form of accident, the dislocation being secondary to the fracture.

* Med.-Chir. Trans., vol. xli., p. 447.

There are two fractures in the neighbourhood of the shoulder joint for which dislocation may be mistaken; namely, fracture of the neck of the scapula, and fracture of the anatomical neck of the humerus. In the former of these, that involving the neck of the scapula, the fracture extends, as has already been described (page 165), from the lower margin of the glenoid cavity, at about the origin of the long head of the triceps muscle, upwards and onwards to the suprascapular notch; and the glenoid cavity, carrying with it the coracoid process, is displaced downwards, together with the head of the humerus, into the axilla. In such a case we have flattening of the shoulder, apparent prominence of the acromion process, a hollow beneath it, and the presence of a foreign body in the axilla; all of them signs which would induce us to believe that dislocation had taken place. Sir Astley Cooper says that the diagnostic signs by which we should recognise the fracture from the dislocation are three: (1) the preternatural mobility and the ease with which the bone can be replaced; (2) the immediate recurrence of the deformity when the extension is removed; and (3) the crepitus, which can generally be detected by placing the finger on the coracoid process when the arm is rotated. And this is true in the great majority of cases; but it may so happen that the fracture is impacted, or the injury may have been overlooked until a certain amount of union has taken place, and these signs would then be absent. The surgeon, under these circumstances, would have to trust entirely in his diagnosis between this fracture and dislocation to the position of the coracoid process, which in the fracture would be carried downwards and a little towards the sternum, and would stand out much more prominently than natural under the skin, whereas in dislocation it would retain its normal position. Even the important

sign which was first pointed out by the late Mr. Callaway, in his Jacksonian Prize Essay for 1849, as characteristic of dislocation and dislocation only, is not true with regard to these cases. Mr. Callaway states, "that in taking the vertical circumference of any shoulder in which dislocation exists, by means of a tape carried over the acromion and under the axilla, an increase of about two inches over the sound side is an invariable concomitant." The same condition would, however, be found to exist in fracture of the neck of the scapula.

The other fracture (fracture of the anatomical neck of the humerus) is not so difficult to diagnose from dislocation. The head of the bone can be felt in the glenoid cavity, and is not in the direction of the axis of the limb. There is a hollow under the acromion, but it is not immediately under that bone, so that the process does not stand out so prominently as in dislocation, and, if the fracture is not impacted, crepitus is easily elicited.

Partial dislocation.—The question as to the possibility of the occurrence of partial dislocation is still involved in a certain amount of obscurity, and by some is regarded as being still unsettled. There can be no doubt that the cases originally described by Sir Astley Cooper as partial dislocations were indeed complete, and many surgeons have believed that they never occur, or that, at all events, their existence has never been satisfactorily proved, either in the living or dead subject (R. Adams, Flower, Hulke). Others have believed that the term "partial" dislocation of the humerus should be restricted to cases where the long tendon of the biceps has been displaced from its groove, or ruptured, and the head of the humerus drawn forwards and upwards under the coracoid process, but not out of the glenoid cavity (Callaway). Such was believed to be the lesion in a case described

by Soden, of Bath, in 1841,* but there seems good ground for believing that this was a case of chronic osteo-arthritis, supervening on injury.† There are, however, two cases on record in which there can be no reason to doubt that a partial dislocation had taken place. In one of these cases, that recorded by Mr. South,‡ there were not only the symptoms during life which pointed to a partial luxation; but there was also the fact that after death, which occurred two days after the accident from other injuries, there was found to be a rent in the capsular ligament such as would permit of a partial displacement of the head of the bone.

In the other case, recorded by Mr. Le Gros Clark,§ though there was no post-mortem examination, the facts observed during life appear to show conclusively that a partial displacement backwards had taken place. Two cases have also been reported by Dr. S. Smith, of New York, which appear in many particulars to resemble Mr. Le Gros Clark's.||

Treatment.—In recent cases, dislocations of the humerus are usually reduced without difficulty, sometimes even the bone will be felt and heard to slip into its place during the necessary manipulations made in the examination of the case; sometimes, also, it is reduced by a bystander or even by the patient himself. It is only in cases where the bone has been allowed to remain unreduced for some time, it may be for a day or two, that difficulties arise; but even these difficulties, with the assistance of anæsthetics, are usually speedily overcome, and it is only in old-standing dislocations, where the parts have become rigid and

* Med.-Chir. Trans., vol. xxiv., p. 212.

† *See* a paper by Mr. Edmund Owen; Med.-Chir. Trans., vol. lviii., p. 377.

‡ Med.-Chir. Trans., vol. xxii., p. 100.

§ St. Thos. Hosp. Reports, new series, vol. v., p. 145.

|| New York "Archives of Clinical Surgery," vol. i., p. 33.

adapted to their new position, that recourse to any mechanical appliance is necessary.

The use of anæsthetics has completely altered the treatment of dislocations and though in those of the shoulder joint, in a patient of moderate muscularity, its employment may not be absolutely necessary, nevertheless, if the patient is very timid, especially if a female, or if much pain is complained of on any attempt at moving the limb, or if the patient is a very muscular person, it should be at once resorted to, and this more especially if an unsuccessful attempt at reduction has already been made.

When the dislocation has existed for some time, it is useless to attempt reduction without bringing the patient thoroughly under an anæsthetic agent, in order not only that adhesions may be freely broken down, a proceeding which, without an anæsthetic, would be exceedingly painful, but also in order that there may be complete muscular relaxation, a condition which will render the chances of success much more certain.

There are three different modes of effecting reduction of dislocations of the shoulder joint, (1) by manipulation, (2) by extension, (3) by mechanical appliances.

By manipulation.—The manœuvres necessary for reducing a dislocation by manipulation may be conducted either with or without an anæsthetic. If the latter, an endeavour must be made to disengage the patient's attention so as to render the muscles lax, for should he anticipate any serious proceeding, he will involuntarily render his muscles tense, and thus defeat the object in view. There are several plans by which the reduction may be accomplished by manipulation, of which, undoubtedly, the simplest is the one advocated by Kocher.*

* Trans. Internat. Med. Cong., vol. ii., p. 416.

The patient is seated in a chair, and the surgeon, standing in front of him, gently presses the elbow to the side, the fore-arm having been first flexed on the arm. The humerus is now quietly rotated outwards until the fore-arm is at a right angle with the body. This is generally all that is necessary, and the head of the bone will be found to resume its normal position with an audible click. Should this, however, not occur, the elbow is now to be raised from the body and rotated inwards till the hand reaches the opposite shoulder. The plan is recommend by Kocher in cases of the most common form of subcoracoid dislocation, but has also proved efficacious in the subglenoid variety.*

Another plan of applying manipulation in dislocations of the shoulder, which very frequently succeeds, is as follows : The patient is seated in a chair, and the surgeon, standing behind him when the dislocation is on the right side, and in front when on the opposite side of the body, grasps the shoulder with his left hand, so as to steady the scapula. The fore-arm having been flexed so as to relax the biceps, the arm is grasped above the elbow with the right hand and raised to a little above the horizontal line. Steady and continuous traction is now made in a direction outwards, with a slight rotatory movement of the humerus; the fingers of the left hand, which grasps the shoulder, being occupied at the same time in pressing the head of the bone back into its normal position.

A third plan of applying manipulation is that usually known as "Smith's method."† This consists in the surgeon standing in front of the patient and grasping the joint with the right hand for the right shoulder, and with the left for the opposite shoulder, so that the thumb rests on the displaced head of the bone and the

* See a case ; *Lancet*, April 14th, 1883.

† H. H. Smith, of Philadelphia.

fingers grasp the shoulder girdle. The elbow being flexed, the arm is seized with the disengaged hand and raised from the side, rotated outwards and extended. As soon as extension has been carried as far as possible the arm is brought suddenly down to the side of the chest, the elbow being made to describe a semicircle in the direction of the sternum, and rotated inwards, the thumb of the hand which grasps the shoulder assisting in guiding the head of the bone into the socket. This proceeding is only applicable to the subcoracoid or subglenoid dislocation; should the displacement of the head of the bone be backwards, the proceeding must be reversed. The surgeon, standing behind the patient, and grasping the shoulder, raises the arm, makes extension, and draws the elbow backwards towards the spine instead of forwards towards the sternum.

Again, a fourth method of manipulation consists in raising the elbow and making it describe a half-circle over the head and face.

2. **Reduction by extension.** — There are many plans by which dislocations of the shoulder joint may be reduced by extension, and though these plans may at first sight appear to be diametrically opposed to each other, they are all, more or less, as was first particularly pointed out by Skey, based on the same principle, namely, that the extension is made in a direction more or less perpendicular to the plane of the glenoid cavity. And it is evident that extension in this direction is necessary, to obviate mechanical obstruction and relax the tension of surrounding muscles; and accordingly we find that, on account of the mobility of the scapula, whether we make our extension downwards or upwards, or horizontally outwards, the direction of the axis of the bone is in a line perpendicular to the surface of the glenoid fossa.

The easiest and the most common plan is to place the patient upon his back on a low couch or bed, or even

on the ground. The surgeon, seated by the affected side and facing his patient, places his foot (of course, unbooted) well up in the axilla, so that the heel presses against the axillary border of the scapula. He then grasps the limb by the wrist and draws it steadily

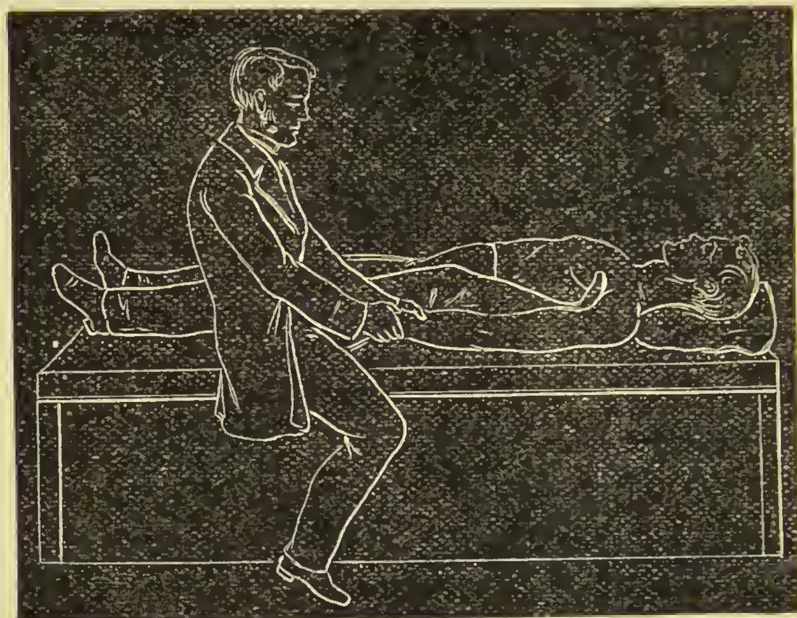


Fig. 61.—Reduction of Dislocation of the Humerus.

The illustration shows the mode of reducing dislocations of the humerus by placing the heel in the axilla.

downwards (Fig. 61). The extension must be continuous and steady, not jerking, and after it has been maintained for some time, should the head of the bone not return to its natural position, as most probably it will do, he brings the arm across the front of the chest of the patient. The foot, then acting as a fulcrum, forces the head of the bone upwards and outwards and so effects the reduction.

Another plan, recommended by Sir Astley Cooper and others, consists in employing the knee, instead of the heel, as a fulcrum. The patient is seated in a low

chair, and the surgeon, standing in front or behind him, according to the side of the body implicated, places his foot on the edge of the chair, so that his knee may be lodged in the patient's axilla. He then grasps the humerus just above the elbow with one hand, and the shoulder girdle with the other, and pulls the humerus downwards over the knee. This is not nearly so good a plan as the heel in the axilla, for not only is the knee too large a body to act as a fulcrum, but also the surgeon has to exert his force in making extension at a considerable disadvantage.

Another plan recommended by Sir Astley Cooper is by horizontal extension. The patient is seated in a chair, or placed in the recumbent position, and the scapula fixed by means of a leather collar, through which the arm is passed; one side of the collar pressing on the acromion, the other on the inferior costa of the scapula. The collar is then held by an assistant or attached to some stationary object on the sound side of the patient. A jack-towel is now fixed by means of a clove hitch to the injured arm just above the elbow, and the arm being raised at a right angle to the body, extension is made by one or more assistants, slowly and steadily, in a direction horizontally away from the patient's body. After extension has been made for some minutes the surgeon places his knee in the axilla, and with his hands on the acromion process, pushes it downwards until reduction is effected.

A better and simpler plan, and one which I have frequently found efficacious when other means have failed, is the one advocated by White, of Manchester. This consists in laying the patient flat on his back, and, having fixed the scapula by means of a jack-towel passed over the shoulder girdle and held by an assistant standing at the foot of the bed, making extension vertically upwards. This plan often succeeds where other means fail, but has seemed to

me to be open to this objection, that it apparently exposes the axillary artery to greater risk of injury than some of the other measures usually in vogue.

Mr. George Lowe has proposed and adopted a modification of White's plan. He causes the patient to sit on the floor with his back to a couch. The surgeon, standing on the couch, places one foot on the top of the shoulder girdle and pulls the arm directly upwards. Mr. Lowe says that in no one instance has this plan failed, in which he has tried it; nor has there been any occasion to give chloroform.*

Mr. Kelly describes another method which he has found successful where others have failed.† This consists in placing the patient on a hard couch, as close to the edge as possible. The surgeon, standing by its side, places the injured arm at right angles to the body, and with his side to the patient presses his hip firmly into the axilla. The fore-arm and hand of the patient is then firmly folded around his pelvis. A rotation of the surgeon's body, so as to describe a quarter of a circle, is then made, so that the back of the operator is turned to the patient, and by this means reduction is said to be effected. I have only tried this method in one case, and then it entirely failed, though reduction was subsequently easily accomplished by means of the heel in the axilla. Possibly, however, this may have been due to want of skill on my part. It certainly appears to possess the advantages over some other methods, that it can be employed without assistance and without any great expenditure of muscular effort.

Reduction by pulleys.—The pulleys are very seldom required in dislocations of the shoulder joint. In my own practice I have never had occasion to use them, and I only remember seeing them employed on

* St. Bartholomew's Hospital Reports, vol. vi., p. 4.

† *Dublin Journal of Medical Sciences*, September, 1882.

one occasion, in an old-standing dislocation of the humerus, and in that case without any good results. The means described above will generally be found sufficient in reducing the dislocation, even in very old-standing cases, if measures have been taken to thoroughly break down all adhesions which may have formed before the attempt at reduction is made. Or if these means fail, a very simple contrivance, to which I have resorted with success on several occasions, gives greatly increased power to the surgeon and generally succeeds in overcoming the displacement. This consists in fastening a jack-towel by means of a clove hitch round the injured arm just above the elbow. The surgeon, seated by the patient, with his heel in the axilla, in the manner described above, places the loop of the towel over his shoulder on the side next the patient and under the opposite armpit. By bending his body backwards, he is enabled to bring the strong muscles of the back into play and make a very considerable amount of extension, quite sufficient, under ordinary circumstances, to reduce any dislocation of the humerus, if all muscular spasm has been removed by placing the patient thoroughly under the influence of an anæsthetic. Should, however, these means fail, recourse must be had to the pulleys. All adhesions having first been thoroughly broken down, the scapula is to be fixed by a leather collar which encircles the shoulder, one band passing under the axilla, the other over the top of the shoulder. This is fastened to a staple in the wall opposite the sound side of the patient. Or the scapula may be fixed by the means employed by Mr. Skey, which does not possess the same disadvantage of compressing the muscles passing from the wall of the chest to the humerus and so rendering them tense. This consists of an iron knob, which is pressed high into the axilla, and to the ends of which

are attached two strong arms, which extend laterally, one in front and the other behind the body, and to the extremities of these is attached a cord by which it is connected to the staple in the wall.* The arm should be bandaged and the pulleys attached to a leather collar, strapped round the arm just above the

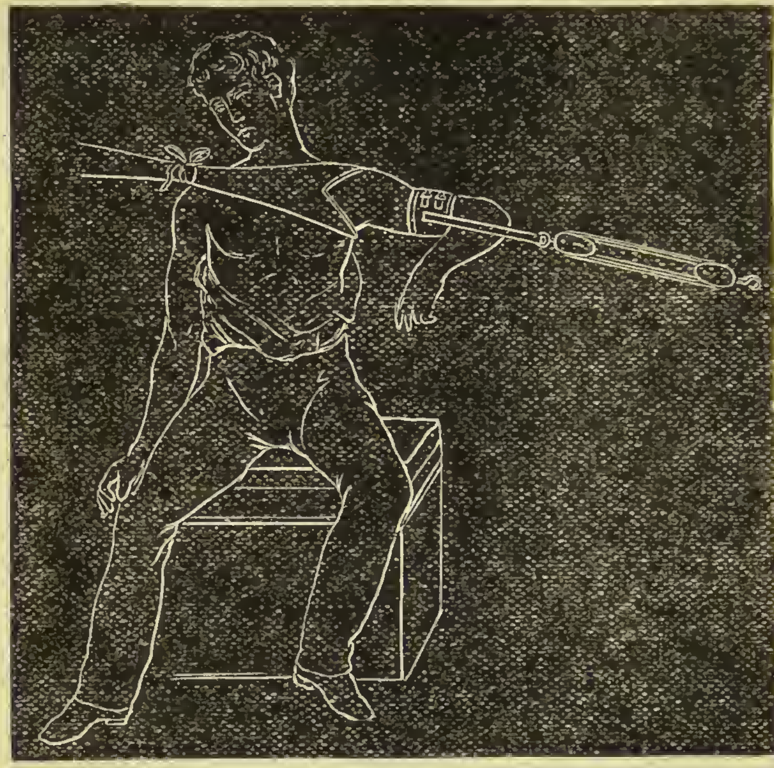


Fig. 62.—Reduction of Dislocation of the Humerus.

The illustration shows the mode of reducing dislocations of the shoulder by pulleys. (After Astley Cooper.)

elbow joint (Fig. 62). Extension is to be made in a horizontal direction, and continued until the head of the bone is felt to move, when the surgeon should endeavour to manipulate or push the bone into place.

After reduction the arm should be bandaged to the

* Bryant; "Disease and Injuries of Joints," p. 227. 1859.

chest, with a pad in the axilla, and maintained in this position for a week. At the end of this time the bandage is to be removed, and the surgeon, with great care and caution, should move the bone in every direction, especially raising the arm from the side. This is done in order to prevent contraction of the capsular ligament, which, especially at its lower part, is liable to become thickened and stiffened from inflammation after injury, if the arm is kept too long close to the side, and thus the movements of the joint, with inability to raise the elbow to a right angle with the body, is the result. After these movements have been made it is safer to bandage the arm again to the side, though some surgeons are content to place it in a sling. The proceeding is to be repeated daily for about three weeks, after which the patient may be allowed to use his arm, cautiously at first; and for some considerable time he should be careful to avoid any violent or excessive exertion, since renewed dislocation is very liable to occur, and each time a joint is dislocated it becomes less secure.

It must be borne in mind that accidents occasionally occur in the attempt to reduce old-standing dislocations of the humerus, either from the employment of undue force or from pathological changes in the part; and it behoves the surgeon to exercise great caution in the conduct of these cases, and not to employ a greater force than is absolutely necessary; and at the same time to conduct all his manipulations with the greatest care, since it would appear from the record of cases that some, at all events, of the accidents which have occurred have been attributable to want of proper attention on the part of the surgeon.

Of these accidents, perhaps the most common is rupture of the axillary artery, of which, according to Mr. Erichsen, there are at least twelve cases in the

records of surgery. No doubt in some of these, as Mr. Callender has shown, the laceration was due to excessive violence employed by unskilful persons. Nevertheless, the accident may occur in the hands of the most skilful surgeon, as in an instance recorded by Mr. Callender himself as having taken place in his own practice.* In these cases the accident is generally attributable to the fact that the artery has become adherent to the humerus, and is lacerated by the breaking down of the adhesions, which tear it away from the bone. For in Mr. Callender's case the dislocation was of six weeks' standing and was reduced with the exercise of very little force by manipulation.† The axillary artery may, on the other hand, be ruptured by the employment of too great force or from the pressure of the surgeon's heel. Such a result occurred in an unfortunate case recorded by Hamilton, where a surgeon attempted to reduce a dislocation by introducing his foot into the axilla without having previously removed his boot.

Rupture of the axillary artery is, of course, more likely to occur in the aged in an attempt to reduce a dislocation, after the vessels have become atheromatous and brittle.‡

The axillary vein has also been known to be ruptured, though not so commonly as the artery, in attempts to reduce old dislocations of the shoulder. The nerves of the brachial plexus have also been said to be injured, producing paralysis.

Another serious accident which sometimes occurs in attempting the reduction of an old dislocation, is fracture of the humerus, and this would appear to arise in the majority of cases from force injudiciously

* *See* also cases in *British Medical Journal,* April 20, 1872, and May 18, 1872.

† St. Bartholomew's Hospital Reports, vol. ii., p. 67.

‡ *American Journal of Medical Science,* October, 1873.

applied as regards its direction. The neck of the bone just below the tuberosities is the part which gives way, and it generally does so in carrying the arm across the chest in endeavours to tilt the bone into its place. The head being fixed, the bone is compressed between two opposing forces, and an indirect fracture is produced. The ribs are also said to have been fractured by injudicious pressure against the wall of the chest.

Lastly, laceration of the skin, subcutaneous tissue, and muscles may result from excessive force employed in the reduction of a dislocation. The anterior fold of the axilla, from the pressure of the foot, has in this way been completely torn across.

In cases in which the dislocation has been left unreduced for a considerable period, it often becomes a question whether any attempt at reduction should be made. This in a great measure must be decided by the amount of inconvenience complained of by the patient. It must be remembered that this is a ball-and-socket joint, and that there is more probability of obtaining a free range of movement even though the bone is not replaced in its normal situation, than would be the case in a ginglymoid joint. (*See* page 329.)

The amount of pain which the patient suffers upon any attempt being made to move the limb must be the great criterion in these cases. If any considerable amount of pain is complained of by the patient upon attempting to move the limb, it is desirable to make the attempt at reduction, even though a very much longer period than the three months, which was originally laid down by Sir Astley Cooper as the limit of time during which reduction should be attempted, has been allowed to elapse. For it is certain that if movement of the limb is attended with pain the patient will abstain as much as possible from using his arm,

and hence the head of the bone will become more and more fixed in its new position, and the functions of the limb will be to a very considerable extent impaired. If, on the other hand, the movement of the bone causes little or no pain, it becomes a very doubtful question whether any attempt at reduction should be made after the bone has been left unreduced for a longer period than three or four months; whether, in the words of Sir Astley Cooper, "the injury which is done in extension is not greater than the advantage obtained in reduction." For it must be remembered that we expose our patient to the risk of all the injuries which have been enumerated above for the sake of a very problematical advantage. For the changes which take place in the old cavity, from which the head of the bone has been removed, are such, that it becomes a doubtful question whether a greater amount of movement will be enjoyed by the patient after the restoration of the bone to its natural situation than can be obtained by the steady and systematic endeavour to form a false joint with the head of the bone allowed to remain in its displaced position.

Compound dislocation of the shoulder is fortunately a rare, though, at the same time, a very grave injury. When it occurs the plan of treatment must depend upon the amount of injury done to the soft parts. When this is slight, the wound being limited in extent and without much contusion and laceration of surrounding tissues, there can be no doubt that the head of the bone should be at once restored to its natural position, the parts cleansed and thoroughly syringed with carbolic acid lotion or some other disinfectant, and efficient drainage provided for. Under these circumstances a fairly satisfactorily result may be anticipated. When, however, the soft parts are much lacerated, and especially if the exposed bone is injured, the safer plan would appear to be to saw off the

head of the bone and convert the case into one of primary excision after injury, unless indeed the injury is so great as to necessitate amputation.

DISLOCATION OF THE ELBOW JOINT.

The elbow joint, in spite of its anatomical configuration and the secure manner in which the bones entering into its composition are articulated together, is not unfrequently dislocated, on account of the considerable degree of violence to which it is exposed.

It is in early life that dislocation of the elbow joint most commonly occurs, for it would appear that at least one half of the cases of dislocation of this articulation occur before the age of fifteen. And it is a curious fact that displacement of this joint should so frequently take place in young children, whereas dis locations of other joints are of very uncommon occurrence, the bones more frequently giving way and fracturing under the application of any severe violence.

Injuries of the elbow joint present more than usual interest on account of the difficulty which is often experienced in making out the exact nature of the lesion which has taken place. It is therefore necessary that these injuries should be somewhat carefully studied.

The directions in which the bones of the fore-arm may be displaced from the humerus are several, and include those in which both bones are displaced, and those in which the position of only one of the two bones is altered, the other remaining in its normal situation. Dislocation of *both* bones may take place either backwards, forwards, inwards, or outwards, and each of these luxations may be complete or incomplete. Or a combination of two of these dislocations may take place, and the bones of the fore-arm displaced backwards and outwards, or backwards and inwards. A still rarer combination has

been reported, where one bone, the ulna, was displaced backwards, and the other, the radius, forwards. When *one* bone only is dislocated it may be the ulna or the radius, the former being only dislocated in one direction, namely, backwards. The radius, on the other hand, may be displaced either backwards, forwards, or outwards, without any alteration in the position of the ulna. Of all these dislocations the one in which both bones are displaced backwards is by far the most common ; some of the other forms being rare instances of injury ; of which, perhaps only one or two cases have been recorded.

Dislocation of both of the bones of the fore-arm backwards.—This luxation is most frequently caused by falls on the palm of the hand, the fore-arm being, at the moment of the fall, extended and carried forwards. Hence it frequently occurs in persons who, when running, stumble, and falling forwards put out their hands to save themselves. The exact modus operandi by which the dislocation is produced is still the subject of doubt, but it would appear probable that when force is applied in this way a great strain is thrown on the anterior ligament of the elbow joint. In consequence of the point of the olecranon pressing against the humerus and acting as the fulcrum of a lever of the second order, the ligament gives way, and the force being applied in an upward direction drives the bones of the fore-arm backwards and upwards behind the humerus.

Malgaigne, however, takes a different view of the case, and maintains that this, and indeed nearly every form of luxation of the elbow joint, is produced by a twist inwards to the ulna, while the fore-arm is semi-flexed. This, he states, would drive the coronoid process inwards, downwards, and backwards, cause rupture of the internal lateral ligament and displacement backwards. Blows or falls, therefore, on the *inner* border

of the fore-arm would, in his opinion, be the most probable cause of this injury; and he states, that this view is borne out by the careful interrogation of patients who have met with this accident.

The dislocation may be complete or incomplete.

In the complete dislocation the coronoid process of the ulna is lodged in the olecranon fossa of the humerus, but in the incomplete form this process is not carried fairly into the fossa, but rests on the trochlear surface of the bone. Some surgeons believe that in the complete form the coronoid process is not actually lodged *in* the olecranon fossa, but merely opposite to it; for they state that the head of the radius impinging against the outer condyle would prevent the process burying itself in the fossa; but that such a condition can exist is evidenced by a preparation in St. George's Hospital museum, where the coronoid process is seen to be lodged in the fossa, and to be almost immovably fixed there (Fig. 63).

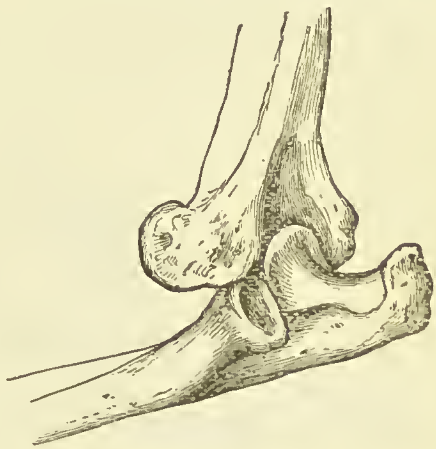


Fig. 63.—Dislocation of both Bones of the Fore-arm backwards.

The dislocation is complete and the coronoid process of the ulna is lodged in the olecranon fossa of the humerus, and is almost immovably fixed in this position. (From a preparation in the museum of St. George's Hospital, series i., 108.)

With regard to fracture of the coronoid process, considerable difference of opinion exists at the present day from what was held some quarter of a century ago. Then it was taught that dislocation backwards could scarcely take place without fracture of the coronoid process. Now, on the other hand, it is believed that fracture of this process rarely or never occurs. The

truth probably lies between these two extremes. It seems a reasonable conjecture, that in those by no means uncommon cases where, after reduction, there is a liability to return of the displacement, that the cause of this liability is a fracture of the coronoid process, the extremity only having been broken off. And as this injury often occurs in young children where the process is cartilaginous, it would be impossible to diagnose the condition by the presence of crepitus. That the coronoid is sometimes broken even in the adult, in dislocation of the bones of the fore-arm backwards, is shown by a preparation in the museum of St. George's Hospital (Fig. 64), but there can be little reason to doubt that in the majority of cases this complication does not exist.

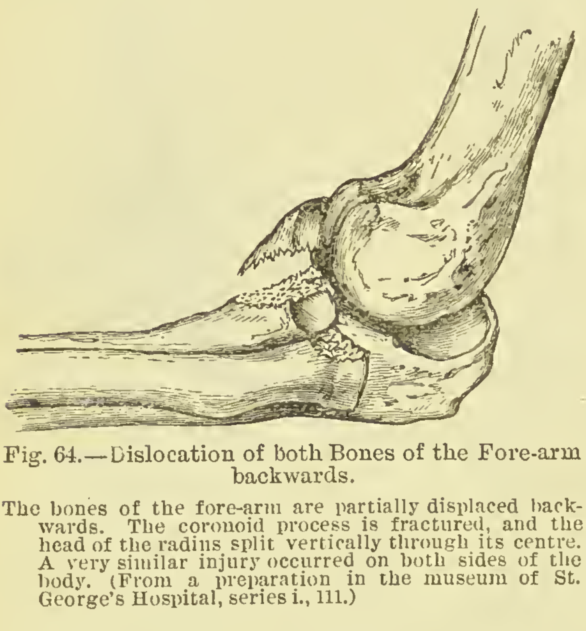


Fig. 64.—Dislocation of both Bones of the Fore-arm backwards.

The bones of the fore-arm are partially displaced backwards. The coronoid process is fractured, and the head of the radius split vertically through its centre. A very similar injury occurred on both sides of the body. (From a preparation in the museum of St. George's Hospital, series i., 111.)

Symptoms.—The patient experiences at the moment of the accident an acute pain in the arm, and is himself conscious that something has given way. Upon examination, there is manifest deformity about the limb. The fore-arm is usually slightly flexed and supinated,* and there is undoubted shortening, which

* This statement differs from Hamilton, who states that he has

is at once apparent. The olecranon process is noticed to project prominently far behind the elbow joint, and the triceps stands out in relief, and can be grasped by the fingers, being felt to be separated from the bone. In front of the elbow joint a firm, rounded tumour can be felt, which can generally be distinguished as the lower end of the humerus, by its peculiar shape (Fig. 65). Finally, the head of the radius can be felt as a prominent rounded swelling

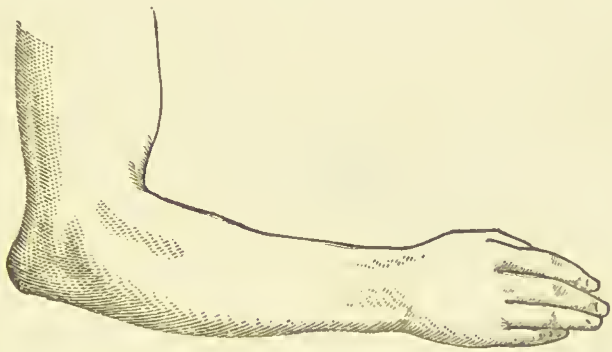


Fig. 65.—Dislocation of the Bones of the Fore-arm backwards.
The figure shows the deformity which is produced in dislocation of both bones of the fore-arm backwards.

behind the external condyle, which moves upon any attempt being made to supinate and pronate the fore-arm. Upon measurement, we find that there is shortening, as compared with the other limb, between the condyles of the humerus and the styloid processes of the radius and the ulna, and that the relative position between the condyles and the olecranon process is altered; these latter characteristics serving to differentiate between this injury and

found the fore-arm and hand "almost constantly in a position of moderate but positive *pronation*" (Hamilton on "Fractures and Dislocations," p. 590, 4th ed.). This, however, does not agree with the observations of most writers, and is certainly not the position in which I have ever noticed the arm to be placed.

transverse fracture of the lower end of the humerus, with which it is liable to be confounded. (*See* page 186.)

If a dislocation backwards at the elbow is overlooked, in the first instance, and allowed to remain unreduced for two or three weeks, there are great probabilities that reduction will never be accomplished. In fact, it rarely happens that a dislocation of this joint is reduced after a period of five or six weeks. Isolated cases are recorded where the attempt has succeeded even after the lapse of fourteen or sixteen weeks; but, as a rule, it does not succeed, and very often mischief has been done in the efforts to effect reduction.

If the dislocation is allowed to remain unreduced, very serious impairment of motion is the result. The power of flexion is entirely lost, that of extension remains to a certain extent. The capability of supinating and pronating the arm is also very seriously impaired.

Dislocation of both bones of the fore-arm forwards.—This is an exceedingly rare form of dislocation, and it would seem almost impossible that it could ever occur without fracture of the olecranon. A sufficient number of cases have, however, been placed on record to establish its existence as a definite form of injury. Malgaigne has collected six well authenticated cases of this injury, and similar cases have been recorded by Dr. Forbes,* Mr. Canton,† and others.

The dislocation can only take place when the fore-arm is in a condition of extreme flexion; at this time the bones entering into the formation of the joint are in such a position that a blow on the end of the olecranon forces the bones of the fore-arm forwards and produces this variety of displacement. Accordingly, we find that the accident usually occurs

* *American Journal of Medical Sciences,* p. 417; October, 1869.
† Ranking's "Abstract," vol. ii., p. 251; 1860.

from falling backwards on the point of the elbow when the fore-arm is flexed to the utmost.

The dislocation may be complete or incomplete. When complete, the olecranon is quite in front of the condyles, the bone being drawn high up above their level, so that the summit of the olecranon rests against the anterior surface of the lower end of the humerus (Fig. 66).

When incomplete, the tip of the olecranon process rests against the articular end of the humerus. Sometimes in these cases there is lateral displacement as well, the bones of the fore-arm being displaced outwards or inwards, as well as forwards. A peculiar case is recorded by Mr. Dale,* where the radius was dislocated forwards and outwards, the ulna simply forwards. In this case there must have been rupture of the orbicular ligament, for in attempting reduction the radius slipped in first, the ulna afterwards, "both with a snap." The head of the radius could be felt prominently outside and below the outer condyle, and the olecranon resting against the trochlear surface of the humerus.

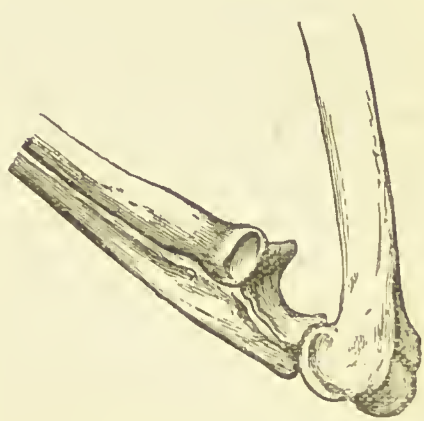


Fig. 66.—Dislocation of the Bones of the Fore-arm forwards.

The dislocation is complete. The olecranon is in front of the condyles, and rests against their anterior surface. (After Bryant.)

Symptoms.—In these cases the signs are much more pronounced and marked in the complete than in the partial displacement, but do not otherwise differ. The fore-arm is usually bent on the arm, and a certain degree of movement is possible; it is considerably

* *Lancet*, vol. ii., p. 597; 1872.

lengthened; the actual amount of alteration in length generally proving to be, on measurement, about an inch. The prominence of the olecranon process is entirely lost, and the condyles of the humerus can be felt at the back of the joint, behind and below the olecranon, with the tendon of the triceps very tense and tightly stretched over them. The sigmoid cavity of the ulna and the head of the radius can usually be felt on the front of the joint.

Lateral dislocation of both bones of the fore-arm.—The lateral dislocations of the bones of the fore-arm are almost always incomplete. In fact, it seems difficult to understand how, on account of the great transverse extent of the articular surfaces, complete displacement can take place. Authors have, however, recorded cases in which they have believed that complete dislocation *outwards* has taken place; though, as far as I am aware, no case of complete dislocation inwards has been recorded. The incomplete dislocation must therefore be regarded as the typical form of injury. Of these, the partial displacement outwards is much more common than the one inwards, on account of the shape of the articular surface.

When the displacement of the bones is **outwards** the sigmoid cavity of the ulna rests against the capitellum or radial head of the humerus, and the radius projects beyond the external condyle. In these cases the fore-arm is flexed and pronated, and there is very little capability of movement, any attempt to flex or extend the limb being attended with great pain. There is a markedly increased width of the limb at the level of the joint, and a prominent projection on the outer side; which, by its cup-shaped upper surface, is easily recognised as the head of the radius. Above this projection is an angular depression. On the inner side of the joint is another projection, situated on a higher level than the one on the outer side, and

a depression below. This latter prominence is the internal condyle. Upon examining the position of the olecranon process, it will be found to be separated by a longer interval than natural from the internal condyle, and to be in close proximity to the external one, if this process can be satisfactorily made out.

When partial displacement takes place **inwards** the sigmoid cavity of the ulna rests against the internal condyle, and in consequence of the fore-arm becoming pronated the head of the radius generally lies a little below and in front of the articular surface of the humerus; it may, however, rest against its trochlear surface, occupying the position of the ulna in the natural condition of the joint. As in the other displacement, so in this, there is flexion and pronation of the fore-arm and increased width of the joint. There is a marked and elongated projection on the inner side, caused by the internal border of the greater sigmoid cavity; this can be traced up to the olecranon process, which entirely conceals and obscures the internal condyle. On the outer side of the joint the external condyle is plainly to be felt standing out prominently under the skin.

In these dislocations the ligaments are necessarily much injured. The two lateral ligaments are always ruptured, and the anterior ligament partially or completely torn. The orbicular ligament is not of necessity injured, and the posterior ligament, on account of its looseness, may escape serious damage. In the internal displacement the ulnar nerve is exposed to great chance of injury from being crushed between the olecranon and the internal condyle.

The dislocations **backwards and outwards** and **backwards and inwards** were formerly described by Sir Astley Cooper as lateral luxations. They differ from the common dislocation backwards merely in the fact that the bones of the fore-arm are

thrown a little to the radial or ulnar side of their normal position, so that the coronoid process, instead of being lodged in the olecranon fossa of the humerus, is lodged on the posterior surface of the external or internal condyle of the humerus, as the case may be. The main difference in the symptoms is that the olecranon process projects more than in the purely backward displacement, and is thrown out of the middle line of the limb and approximated to the tip of the condyle on which it is lodged.

Dislocation of the ulna alone.—The ulna by itself is only dislocated in one direction, viz. backwards; and there appears to be very little known of this rare form of injury, and very different accounts of it have been given by different authors. The only dissection, as far as I am aware, which has been made of this injury, is one which is described by Sir Astley Cooper, and in this case there appears to have been a partial displacement of the head of the radius as well, so that the case cannot be regarded as one of true dislocation of the ulna alone. * And, indeed, it seems difficult to understand how *complete* dislocation of the ulna can take place unless the humerus or radius is fractured, or there is extensive rupture of the oblique ligament and interosseous membrane, as well as the orbicular ligament. Even in Sir Astley Cooper's case, where the head of the radius was partially displaced these ligaments were ruptured. It is quite possible, however, that the upper end of the ulna may be *partially* displaced from the lower end of the humerus, without any fracture or without rupture of any other than the orbicular ligament, and to this condition most of the cases of dislocation of the ulna alone ought, I

* Sir Astley Cooper says, "The radius rests upon the external condyle and has formed a small socket for its head, in which it was able to roll" ("Fractures and Dislocations," p. 450; 1842).

think, to be referred. The coronoid process would, under these circumstances, rest upon the trochlear surface of the humerus, and not be carried up as far as the olecranon fossa.

Symptoms.—This form of dislocation may be recognised by the projection of the olecranon behind the joint, at the same time that the head of the radius is felt rotating in its natural position. The fore-arm is generally partially flexed, though it may be flexed to a right angle, and strongly pronated, and at the same time inclined inwards, so that the fore-arm forms an obtuse angle with the arm along its inner border. The olecranon process projects, as in the backward displacement of both bones, and the triceps can be felt to be raised from the shaft of the bone; but the radius, instead of forming a prominent rounded swelling at the back of the external condyle, occupies its normal position and can be felt moving in its socket.

Treatment.—In all the above described dislocations of the elbow joint the reduction can generally be effected by the same plan. The great obstacle to reduction is the hitching of the olecranon or coronoid processes of the ulna against the lower end of the humerus, and these may be best freed by the plan described and advocated by Sir Astley Cooper, and the one which is almost universally adopted by surgeons up to the present day. "The patient is made to sit upon a chair, and the surgeon, placing his knee at the front of the elbow joint, in the bend of the arm, takes hold of the patient's wrist. At the same time he presses on the radius and ulna with his knee, so as to separate them from the os humeri, and thus the coronoid process is thrown from the posterior fossa of the humerus; and whilst this pressure is supported by the knee, the arm is to be forcibly but slowly bent, and the reduction is soon

effected."* Some surgeons recommend extension directly downwards; one person grasping the humerus, another pulls in a straight direction downwards, as if for the purpose of simply elongating the arm. When by this means the coronoid process is pulled below the level of the articular surface of the humerus, the action of the muscles speedily drags it into position. Others again recommend that the fore-arm should be pulled directly backwards, so as to relax as much as possible the triceps muscle. In recent cases, however, almost any extension is sufficient to effect reduction, a little steady traction being sufficient to disengage the coronoid process, when the bones, from muscular action, have at once a tendency to assume their natural position.

When some time has been allowed to elapse without reduction considerable difficulty will be experienced in overcoming the displacement. All adhesions having been broken down by various movements, an attempt should be made to effect reduction by the various plans mentioned above; or should this fail, recourse may be had to the pulleys in order to bring the bones of the fore-arm downwards, when reduction may be effected by sudden and acute flexion. Care must be taken, in using the pulleys, not to fracture the bones.

Up to eight or ten weeks an attempt may be made to reduce any of these dislocations; after this time, the decision as to the advisability of attempting reduction must depend upon the amount of motion enjoyed and the position of the fore-arm. When this is extended and no movements exist any attempt is justifiable. If, on the other hand, a fair amount of motion is present and can be accomplished without pain, it is better not to attempt reduction, a proceeding which may be attended with permanent damage to the

* *Op. cit.*, p. 441.

patient. Occasionally in old unreduced dislocations of the elbow joint, where the fore-arm is fixed in an extended position, it may be advisable to subcutaneously divide the tendon of the triceps muscle in order to permit of placing the limb in a more useful position.*

Dislocation of the upper end of the radius.—The head of the radius may be dislocated either forwards, backwards, or outwards, without any displacement of the ulna from its anatomical relations. With regard to the first two, forwards and backwards, considerable discrepancy of opinion appears to exist as to which is the more common.†

In both forms of the dislocation the injury may be caused by falls on the hand; in the one instance where the dislocation is forwards, the *lower* end of radius is driven backwards and the upper end tilted forwards and dislocated; or in the other the whole bone is driven backwards and the head of the bone displaced on to the back of the outer condyle. The form of dislocation would appear, therefore, in cases where it is a result of a fall on the hand, to depend upon the position of the fore-arm at the time of the

* See the account of two cases in which this was done; *Lancet*, vol. i., p. 191; 1858.

† Sir Astley Cooper believed that dislocation forwards was the more common; and Mr. Erichsen says "that it is certainly the more common." In this opinion Hulke, Fergusson, and Hamilton concur. On the other hand, Boyer, Velpeau, Guthrie, Chelius, and others are of opinion that the backward dislocation is the more common. Dr. R. Adams also believes that luxation backwards is more usual than that forwards, and gives various anatomical reasons for its greater frequency ("Cyclop. of Anatomy and Physiology," vol. ii., p. 74). And Professor Humphrey says: "The displacement of the radius backwards, according to the experience of Sir A. Cooper, is a less frequent occurrence than forwards, which we should have been scarcely led to expect from a consideration of the anatomy of the parts and of the direction in which the disturbing forces are usually received" (Humphrey on "The Skeleton," p. 424).

accident, as to which way the radius shall be driven.

Dislocation forwards.—This is generally produced by falls on the hand when the fore-arm is in a state of extreme pronation and extended. It may also be caused by a direct blow on the back of the upper end of the bone. The head of the bone rests on the anterior surface of the humerus, in the hollow above the external condyle, on the front of the condyloid ridge (Fig. 67). In these cases there is considerable laceration of the ligaments, the orbicular, the anterior, and sometimes the oblique ligament have been found to be torn. Instances, however, have been recorded where a partial luxation has been said to have taken place without actual rupture of the orbicular ligament, which was merely greatly stretched.

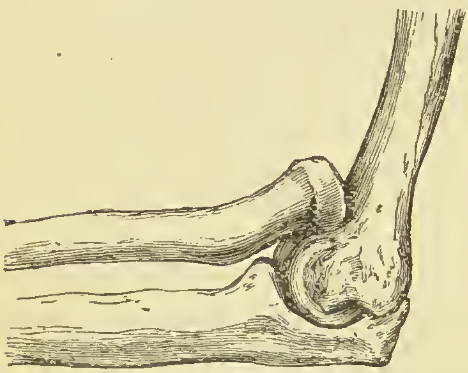


Fig. 67.—Dislocation of the Head of the Radius forwards.

The head of the radius rests on the anterior surface of the humerus, in the hollow above the external condyle, in front of the external condyloid ridge.

Symptoms.—The fore-arm is semiflexed and maintained in a position midway between supination and pronation. If any attempt is made to flex the fore-arm the head of the radius will be felt to impinge against the surface of the humerus and prevent the flexion. The head of the radius can generally be felt in its new position, and will be found to rotate upon any attempt to pronate or supinate the fore-arm. At the back of the joint just below the external condyle will be found a depression in the place usually occupied by the head of the radius.

Dislocation backwards.—This form of dislocation may also be produced by falls on the hand, the whole bone being driven backwards; or it may be caused by a direct blow upon the front of the upper part of the shaft of the radius. In these cases the head of the bone rests on the back and outer surface of the external condyle (Fig. 68).

Symptoms.—The fore-arm is flexed slightly and maintained in a position of pronation. The limb is inclined outwards from the elbow joint. Flexion and extension can be performed to a limited extent, but the power of pronation and supination is lost. The most palpable sign of this dislocation is the projection of the displaced head behind the external condyle where it can scarcely fail to be recognised.

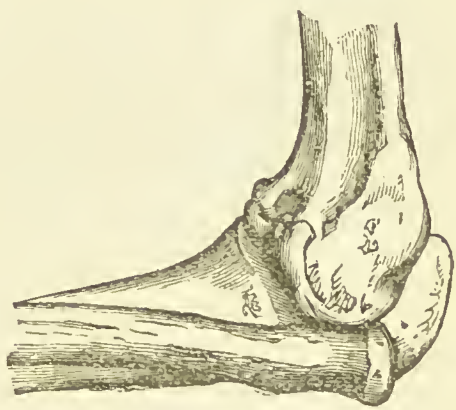


Fig. 68.—Dislocation of the Head of the Radius backwards.

The head of the radius rests on the back and outer surface of the external condyle. (From a preparation in the museum of St. George's Hospital, series i., No. 109.)

Dislocation outwards is a very rare form of injury, which was first described by Sir Astley Cooper, who records one example of it. He describes the radius as being dislocated upwards and outwards above the external condyle. In this position the bone could be easily detected under the skin, and could be felt to rotate upon pronating and supinating the fore-arm.

Treatment.—Dislocations of the radius, in whatever position the displacement has taken place, may generally be reduced in the same way. The upper arm is to be grasped by an assistant, just above

the elbow joint, and firmly held. The surgeon then extends the wrist, and after he judges that sufficient extension has been made, suddenly flexes the fore-arm on the arm, at the same time endeavouring to push the head of the radius back into its place.

Compound dislocation of the elbow joint much more commonly takes place than a similar accident in the shoulder. If the injury to surrounding parts is slight, the bones should be reduced, the wound closed, free drainage provided for, and an attempt made, as early as possible, to obtain some movement in the joint. Should, however, there be more laceration, and especially if the ends of the bones are much comminuted, primary excision should be resorted to, and these cases usually do well. If the amount of laceration is excessive, and especially if the main artery or nerves are injured, amputation is, of course, the only resource; but it is astonishing how much injury may be recovered from after excision, and a limb ought not to be lightly condemned.

Dislocation at the Wrist Joint.

The radio-carpal joint is rarely the seat of dislocation. When it does take place it may do so either forwards or backwards. In the latter variety, which appears to be the more common, the carpus and hand are displaced backwards, the lower end of the radius and ulna being driven forwards in front of the first row of the carpus, with their extremities resting on the flexor tendons which pass under the anterior annular ligament (Fig. 69).

The usual way in which this dislocation is produced is by falls on the palm of the hand. This form of injury may, and generally does, either produce a Colles's fracture of the radius, or in younger persons a dislocation at the elbow joint; but it may also, under

exceptional circumstances, produce a displacement of the carpus backwards at the wrist joint.

The deformity which is present resembles to a great extent that produced by a Colles's fracture. There is a large prominence on the dorsal surface of the wrist, terminating in the carpal bones, and a projection on the anterior surface, somewhat nearer the fingers than the dorsal one. The hand is inclined backwards, and the fingers are flexed. In these respects it resembles a Colles's fracture; but the position of the styloid processes and their relation to each other and to the fingers is a sure test by which the differential diagnosis between the two injuries may be established. The styloid process of the radius in this injury remains in its normal position to that of the ulna and to the bones of the fore-arm, whereas in the fracture it is carried backwards with the hand.

Fig. 69.—Dislocation of the Carpus backwards.

The scaphoid bone is broken transversely; its upper half, together with the semilunar, remains in connection with the radius. The distal end of the scaphoid and the rest of the carpal bones with the hand, are dislocated backwards, but do not overlap the end of the radius. (From a preparation in the museum of St. George's Hospital, series i., No. 114, *a*.)

Dislocation forwards.—This dislocation appears to be of extreme rarity as the result of accident, but is occasionally met with as a congenital affection. According to Sir Astley Cooper, it is produced by falls upon the *back* of the hand, by which the "radius and ulna are thrown upon the posterior part of the carpus, and the carpus itself is forced under the flexor tendons." Mr. Bransby Cooper, however, relates a case in which the accident was produced by a fall on the palm of the hand. The case is curious, since the

same accident appears to have produced a forward dislocation on one side of the body, and a backward displacement on the other. It was that of a boy, aged 13, who was thrown from a horse and fell on the palms of the hands. The left carpus was found to have been dislocated backwards, the right forwards. Considerable care was taken to ascertain the exact nature of the accident and to determine what parts came into contact with the resisting force, and it was noted that there was extensive bruising in the palms of both hands, but not the slightest bruise on the back of either hand.

In this dislocation, the lower end of the radius and ulna project on the dorsal surface of the wrist, and unless the swelling is very great the concave outline of the two bones can be fairly perceived. The carpus projects on the palmar surface. The symptoms, therefore, in this luxation are just the reverse of those which may be observed in the other.

Treatment. — The reduction in these cases, whether the displacement is forwards or backwards, is generally easy. Extension, combined with firm pressure on the projecting carpus, is usually all that is necessary to ensure reduction. After this has been accomplished, the hand should be retained on a splint for a few days, and passive motion commenced early and persevered in for some time, as otherwise considerable loss of movement may be the result.

Dislocation of the radius from the ulna at the inferior radio-ulnar joint.—This dislocation, which was formerly described by Sir Astley Cooper as dislocation of the lower end of the *ulna* from the radius, is of very unfrequent occurrence. It is always produced by violent twists to the hand, or any injury which produces excessive pronation and supination; thus Desault relates a case in which the accident happened to a woman while violently wringing out some clothes.

The radius may be displaced either forwards or backwards, the former dislocation being the more common of the two and being produced by extreme pronation of the fore-arm, the latter occurring during supination. The triangular fibro-cartilage is torn, and owing to this and to the shallow sigmoid cavity on the radius, a recurrence of the displacement is very likely to take place after reduction.

In the **forward** dislocation the fore-arm is twisted and in a condition of forced pronation. The hand is displaced forwards, and the inferior part of the fore-arm, that is, the space between the styloid processes of the radius and ulna, much narrowed. The lower extremity of the ulna projects posteriorly, tensing the skin in this situation and sometimes protruding through it. In the **backward** dislocation the fore-arm is twisted and in a position of supination. The hand is displaced backwards, and the extremity of the ulna projects under the skin at the front of the wrist. These dislocations are readily reduced by extending the hand and applying pressure to the radius in order to force it back into its place. The hand must afterwards be retained on an anterior and posterior splint for at least three weeks, and the patient afterwards cautioned not to make any violent movements of his wrist for some time, or else a recurrence of the displacement will take place.

Dislocation of the Bones of the Carpus from one another.

The bones of the carpus are so firmly united together, and the amount of motion between any two bones is so limited, that we should scarcely be prepared to believe that dislocation could take place. There is, however, a weak spot in these joints; viz. between the head of the os magnum and the scaphoid and semilunar bones. During flexion of the wrist, the head of

the os magnum glides backwards on the concave articular surface formed by the scaphoid and semilunar bones and presses against the dorsal ligaments attached to the posterior surfaces of these bones, where it can be plainly felt as a rounded prominence under the skin. Should any violence be applied while the hand is in this position, the ligamentous fibres may be torn and the bone partially dislocated from the cavity in which it is placed.

The accident, therefore, always occurs in the same way, from violent falls or blows on the back of the hand while the wrist is in a condition of flexion. It is said to be more common in women than in men.

The injury can be at once recognised by the presence of a hard, circumscribed tumour in the situation of the os magnum, which becomes more prominent during flexion and partially disappears during extension. It is generally easy of reduction, but is very liable to reproduce itself upon any movement of flexion.

Dislocations of the other carpal bones have been described, such as the pisiform and semilunar. Generally the injury is produced by great violence, and there are other lesions as well.

Dislocation of the Metacarpal Bones.

The metacarpal bones can hardly be separated from the bones of the carpus, except as the result of great violence. This accident, therefore, rarely occurs, unless as the result of extensive injury by which the bones are fractured as well, with such laceration of soft parts as necessitates amputation, such as might be produced by a gun-shot accident, or the bursting of a fowling piece, or the fall of a heavy weight upon the hand. Occasionally, however, cases have been recorded where one or two of these bones have been dislocated, and of these, dislocation of the first

metacarpal bone is undoubtedly the most common. This bone may be displaced from its articulation with the trapezium and trapezoid, either backwards or forwards, more commonly the former. When the dislocation is **backwards**, the accident is generally produced by falls on the external or radial border of the hand. The base of the bone, under these circumstances, rests on the dorsum of the trapezium, where it forms a remarkable prominence under the skin. The bone itself is inclined towards the palm of the hand. The nature of the lesion can be at once recognised, and the dislocation is generally easily reduced by simple extension, at the same time that the bone is pressed back into its proper position. At the same time it frequently happens that as soon as the pressure and extension are removed the displacement will recur.

In the dislocation **forwards** the base of the bone is thrown inwards and forwards and rests between the trapezium and the end of the first metacarpal bone. It here forms a protuberance which can be plainly felt buried beneath the small muscles of the thumb. The bone itself is inclined backwards and outwards, and cannot be approximated to the other fingers. There is generally a considerable amount of swelling and pain.

The reduction is usually easy, and is to be effected by extension, assisted by pressure, on the prominent base of the bone. After reduction the hand should be maintained on a splint for two or three weeks, since a recurrence of the displacement is likely to occur.

When the other metacarpal bones are dislocated from the carpus it is generally backwards, and the lesion may be at once recognised by the prominence of the bones on the back of the wrist.* They can

* Mr. Raven records a case in which the second, third and

for the most part be easily reduced by simple extension.

Dislocations at the Metacarpo-phalangeal Joints.

Dislocation at these articulations is not a common accident. In a large number of cases in which it does occur it is produced by falls upon the hand, and appears to take place more frequently in young persons. The phalanges are generally displaced backwards on to the backs of the heads of the metacarpal bones, the forward dislocation rarely, or probably never, occurring except in the thumb and index finger.

Dislocation at the metacarpo-phalangeal joint, whether backwards or forwards, very much more frequently takes place in the thumb than in any of the fingers. Here it is by no means an uncommon accident, and is interesting on account of the difficulty which frequently exists in effecting reduction. The phalanx of the thumb may be displaced from the metacarpal bone either backwards or forwards. The former is, however, much the more common of the two. It is generally produced by falls on the hand with the fingers outspread, or by blows on the palmar surface of the thumb.

The base of the phalanx is driven backwards and upwards on to the back of the head of the metacarpal bone. In consequence of this the head of the metacarpal bone is driven forwards between the small muscles of the thumb, which are inserted into the inner and outer side of the base of the first phalanx, and these muscles contracting around the constricted neck of the bone, fix it in this position very much in

fourth metacarpal bones were dislocated backwards by a kick from a horse. In the Hunterian Museum there is a preparation showing partial dislocation of the fourth metacarpal bone.

the same way as a button is fixed in a button-hole (Fig. 70). The contraction of the extensors and the long flexor of the thumb at the same time pull upwards the phalanx on the back of the metacarpal bone and increase the displacement. The lateral ligaments, either one or both, are usually torn, though cases have been recorded where these ligaments have been said to have remained entire.

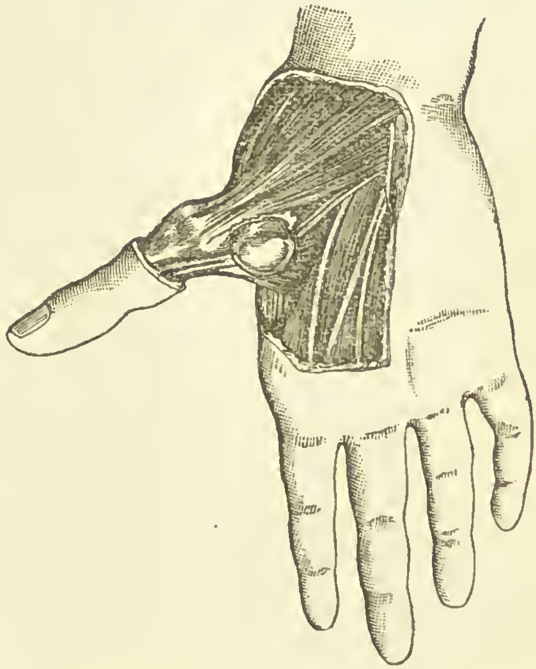


Fig. 70.—Dislocation of the Metacarpo-phalangeal Joint of the Thumb.

The head of the metacarpal bone has been forced forwards between the two heads of the flexor brevis pollicis, so that the neck of the bone is tightly embraced by this muscle. (After Fabbri.)

The signs of this injury are generally very evident. The thumb presents a very peculiar and characteristic deformity. The proximal phalanx is bent backwards so as to produce almost a right angle with the metacarpal bone, and at the same time the terminal phalanx is flexed, or semiflexed, on the proximal one. Thus the thumb presents a peculiar S-shaped curve (Fig. 71). The head of the metacarpal bone may be seen and felt on the palmar aspect of the thumb, and the base of the first phalanx can sometimes be detected in the angular concavity formed between the two bones.

The reduction of this dislocation is sometimes attended with great difficulty, at other times it can be accomplished with ease. Many reasons have been assigned to account for this difficulty. Among others, it has been suggested by some that the anterior ligament is torn from one of its attachments and falls between the joint surfaces; others believe that it is due to the resistance of the lateral ligaments, which, in cases where this difficulty is present, are not torn; others again imagine that it is due to the long flexor tendon becoming displaced and entangled behind the extremity of the bone.* Another theory, which was formerly accepted as the correct one, was that it was simply due to the contraction of the muscles of the thumb inserted into the base of the first phalanx and to the shortness of the member, which did not permit of sufficient leverage. The reason which is now, however, almost universally accepted is that it is due to the head of the metacarpal bone being "button-holed" by the tendons of the short flexor muscle, with its sesamoid bones, and the other muscles attached to the inner and outer side of the base of the proximal phalanx.

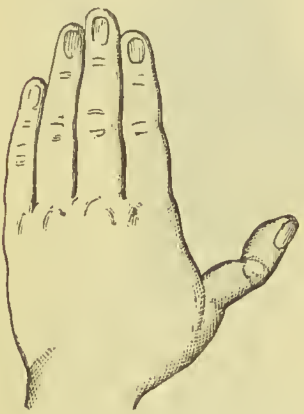


Fig. 71.—Dislocation of the Metacarpo - phalangeal Joint of the Thumb.

The figure shows the deformity which is produced in dislocation backwards of the proximal phalaux of the thumb. (After Erichsen.)

If this is so, it is quite clear that mere extension can never reduce the dislocation. The more extension made, the more tense these short muscles would become, and the firmer the neck of the metacarpal bone would be gripped. Great force was formerly

* *See* a paper by Mr. Wordsworth, *Lancet*, vol. ii., p. 443; 1863.

applied to endeavour to overcome this dislocation by extension, and of course without avail. In order to effect reduction, it is generally desirable to administer an anæsthetic, certainly if the dislocation has existed for some time. The metacarpal bone is then to be forcibly adducted into the palm of the hand, so as to relax as far as possible the muscles, and firmly held there by an assistant. The surgeon now bends the phalanges forcibly backwards on the metacarpal bone and makes extension, while the bones are in this position, away from the hand. When by this means he has freed the bone from its entanglements a sudden movement of flexion will generally succeed in restoring it to its place. Sometimes, on account of the shortness of the member, there is some difficulty in getting a secure grip on the bone, and in order to obviate this various apparatus have at different times been devised. Of these, perhaps the most useful are the so-called "American forceps," which are so constructed with straps which cross each other, that when the blades are closed the thumb is held firmly (Fig. 72). If these should not be at hand, a clove hitch, made out of a strip of soft chamois leather, or even tape, answers every purpose; or a

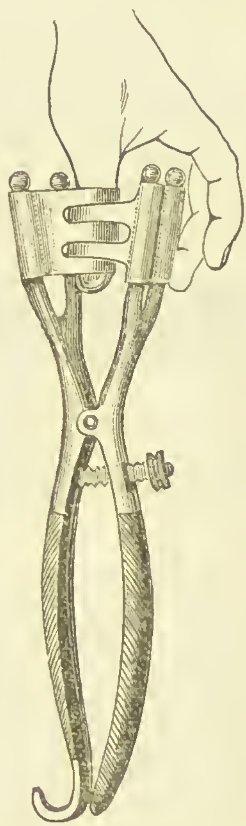


Fig. 72.—American forceps for reducing Dislocations of the Metacarpo-phalangeal Joint of the Thumb.

useful means of extension may be easily made by taking a piece of wood the size and shape of a paper knife and boring two parallel rows of holes, about an inch apart; the palmar surface of the thumb is then laid on the wood, and pieces of tape passed over the thumb and through the holes are securely tied on the opposite surface of the wood (Fig. 73). If these means fail to overcome the displacement, recourse must be had to subcutaneous division. A small tenotome is introduced on either side of the joint and the tense structures divided by a sweep of the knife. The section must of course include the tendons of the flexor brevis and other muscles attached to the phalanx, and also probably the lateral ligaments if these structures have not been torn. Professor Humphrey, believing that the cause of displacement is simply due to the flexor brevis pollicis, has suggested that a blunt hook should be introduced through a small incision at either side of the joint and the tendons pulled aside.

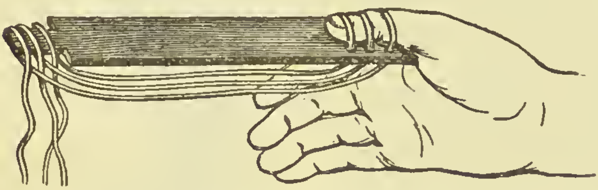


Fig. 73.—Levis's Apparatus for reducing Dislocations of the Metacarpo-phalangeal Joint of the Thumb.

Dislocation of the metacarpo-phalangeal joint of the thumb **forwards** is a much more rare accident than the preceding. Nélaton has recorded four examples,* and Hamilton two,† which had fallen under his own observation.‡ It is generally produced by falls or blows on the flexed thumb; thus it has been known

* Path. Soc. Trans., vol. ii., p. 23.

† "Fractures and Dislocations," p. 627. 1871.

‡ Cases of dislocations of the phalanx forwards are recorded in the Path. Soc. Trans., vol. iv., p. 250, and vol. xxxi., p. 216.

to be caused by a blow with the closed fist, the force of the blow being received on the back of the head of the first phalanx. In these cases, the base of the first phalanx rests on the front of the head of the metacarpal bone, and the muscles inserted into it are carried forwards with the bone, so that no "button-holing" takes place. The signs which characterise this dislocation are usually so well marked that no error can occur as to the diagnosis, though the displacement may, to a certain extent, be masked by the swelling which usually takes place, and is generally considerable. The metacarpal bone can be felt projecting posteriorly, and the base of the first phalanx can be also perceived forming a prominence on the palmar surface of the thumb.

Reduction is, as a rule, easily accomplished by flexing the thumb forcibly into the palm of the hand, the same impediments not existing in this form of dislocation as in the displacement backwards. The surgeon grasps the thumb of the patient in such a manner that his index finger lies across the palmar surface of the dislocated joint, and his thumb rests on the back of the proximal phalanx. His forefinger now acts as the fulcrum of a lever, and by making firm extension, and then forcibly flexing the phalanges over his finger, the bone will resume its proper position. In one of the cases recorded by Nélaton, reduction could not be effected, and the dislocation remained unreduced, and in one of Hamilton's cases reduction was followed by intense inflammation, with suppuration under the palmar fascia, and in the end the thumb was almost completely anchylosed.

In some persons this joint can be voluntarily dislocated simply by muscular contraction. Under these circumstances, however, the dislocation is not complete, the one articular surface not entirely leaving the other.

Of the other fingers, dislocation at the metacarpo-phalangeal joint of the little finger appears to most frequently take place, and after this the index finger. The other fingers may be also, though less commonly, dislocated at this articulation, and the injury may involve one or more of the digits. These luxations are almost invariably backwards, no case, as far as I am aware, having been recorded of dislocation of any of the fingers forwards, except the index finger. The projection of the displaced phalanx in these cases is so marked as to leave no doubt as to the nature of the injury, and reduction can usually be readily effected by forcible extension combined with flexion.

Dislocation of the phalanges occasionally occurs, generally at the joint between the first and second phalanges. It is extremely doubtful whether dislocation of the terminal phalanx ever takes place, except as the result of some form of violence which severely lacerates the soft structures around the joint and necessitates amputation. The displacement may be either partial or complete, but in both cases produces such marked deformity as to be at once recognised. They can be readily reduced by extension combined with pressure over the displaced bone.

CHAPTER III.

DISLOCATIONS OF THE TRUNK.

DISLOCATION OF THE RIBS.

THE ribs may be dislocated from the bodies of the vertebræ, and the accident is one which requires notice, though little can be said on the subject, since it is one of extreme rarity, in which the diagnosis can

be, at the best, conjectural, the treatment unsatisfactory, and the injury seldom an accident *per se*, but usually complicated with some other and more serious lesion, such as fracture of the spine or ribs, which renders the dislocation merely a subordinate part of the case.

The immunity from injury which these joints possess is due in a great measure to the limited range of movement which they enjoy, and to the impossibility of their being strained by any voluntary or involuntary effort.

These dislocations were first described by Ambrose Paré, but many others doubted whether they actually ever occurred, and Boyer absolutely denied their possibility. The first case in which the injury was actually demonstrated by dissection is recorded by Henkel, in a man who fractured his spine by a fall into a ditch, and who died on the fifteenth day from the effects of the injury to the spine. In this case the eleventh rib was found to be displaced forwards from its articulation with the vertebræ.* Other cases have since been recorded, which leave no room for doubt that this injury may occasionally occur. When it does, the displacement always appears to take place in the same direction, that is to say, the head of the rib is displaced forwards and inwards on to the front of the spine.

The injury is produced by falls or blows upon the back, and is usually complicated with fracture of either the spine or the rib itself. The floating ribs are the ones which are most frequently the subject of this injury, but it may also occur in any of the true ribs, including the first, of which a case is recorded as having occurred in the Middlesex Hospital.†

The diagnosis in these cases is difficult, and it is

* *Gazette Médical;* 1834.

† "System of Surgery," vol. i., p. 816.

almost impossible to give a positive opinion, since the symptoms are almost identical with those of fractured rib. There may be a deep depression, but this is often masked by the swelling, with pain and increased mobility, and an absence of crepitus. Buttet, who wrote on this subject, and described a case, based his diagnosis on the presence of a very distinct sound, which was *not* the crepitus produced by a broken bone, and upon the fact that the rib moved throughout its entire length when pressure was made on its sternal extremity.* Chelius also speaks of this same sound, which he describes as a "rustling," and which differs from the crepitus produced by fracture.

The treatment in these cases is unsatisfactory. Nothing can be done to effect reduction, and the case must be simply treated (if diagnosed) as one of fractured ribs, the chest being swathed in a rib roller, so as to ensure quiet as far as possible, and the displaced rib allowed to form new attachments in its displaced position. Bransby Cooper relates a case in which a patient, having been thrown from his horse, was treated for fractured ribs, and supposed to have entirely recovered. Upon his death several years afterwards from fever, it was found that the head of the seventh rib had been thrown on to the front of the corresponding vertebra, and had never been reduced, but was anchylosed in this position.

Dislocation at the costo-chondral joints.—Dislocation of the costal cartilages from their articulation with the anterior extremities of the ribs rarely takes place. When it does the cartilage is displaced inwards, so that the end of the rib forms a prominence in front of the corresponding cartilage. The accident is generally produced by direct violence, as in the case recorded by Sir Charles Bell in his "Surgical Reports," in which most of the costal cartilages

* Mém. de l'Acad. Roy. de Chir., vol. iv., 1768.

were dislocated from the ribs in consequence of the person being pressed between a post and a waggon. In one case, recorded by Carbonell, it was caused by a fit of coughing. In some cases a single costal cartilage has been displaced, in others several. The injury is to be recognised by the prominence of the end of the rib and the depression internal to it in the position of the corresponding cartilage, and by the absence of bony crepitus. The treatment is the same as for fractured ribs.

Dislocations at the costo-sternal joints.—The costal cartilages are more frequently displaced from the sternum than they are from the anterior extremities of the ribs with which they articulate. One cartilage only may be displaced, or several, and the dislocation may be complicated with fracture of the sternum or the ribs.

The accident may be caused by violent compression of the chest, as when a person is run over or falls from a scaffold, or it may be produced by muscular action. Thus, Sir Charles Bell records a case where the injury was produced by a patient throwing his hands, with heavy dumb bells in them, violently backwards; and B. Cooper a case where it occurred in a weakly boy from the violent action of the pectorals in kneading bread. This accident, from the recorded cases, would appear to be more common in youth, when the connections between the cartilages and the sternum are looser than in advanced life, when the joints often become obliterated. The cartilage is almost invariably thrown forwards on to the front of the sternum, though, when the dislocation has been produced on the dead body, the displacement is different, the cartilage being displaced backwards behind the sternum.

The diagnosis does not present any difficulty. The pain in the situation of the lesion, with the prominence

of the cartilage on the front of the subcutaneous sternum, following a severe injury or violent muscular effort, is sufficient to establish the nature of the case.

The reduction may be accomplished by arching the body backwards, and, at the same time, making firm pressure on the prominence of the displaced cartilage or cartilages. This may be best done by laying the patient flat on a table or board with a sand-bag down the middle of the back. The shoulders and sides of the chest are then to be depressed, and if, at the same time, the displaced cartilage is pressed upon, it will generally resume its position suddenly and with a sound. There is often some difficulty in retaining the cartilage in position after reduction, and Sir Astley Cooper recommends that a pasteboard shield should be made and accurately moulded to the chest.

Dislocation of the cartilages from each other.—This, of course, can only occur in the cartilages of the lower ribs, from the sixth to the tenth, which articulate with each other. It may occur from a severe muscular effort, as in lifting a heavy weight, or from a violent muscular strain to prevent the body falling backwards. Or it may be produced by falls on the back across some prominent object, so that the body is bent violently backwards. The lower cartilage is generally displaced forwards from the upper one. There is severe pain, and the prominence of the cartilage is readily detected. Reduction is to be effected by directing the patient to take a full inspiration, and while the chest is maintained in this condition the surgeon makes firm pressure over the displaced cartilage, at the same time endeavouring to press the superior cartilage upwards so as to disengage the one from the other. The dislocation is, however, difficult to reduce and very liable to recur after reduction, so that in the majority of cases the patient recovers with a certain amount of deformity.

DISLOCATION OF THE FIRST AND SECOND PIECES OF THE STERNUM.

Dislocation between the manubrium and gladiolus sterni has so much in common with fracture that some writers employ the terms dislocation and fracture of the sternum as synonymous, and include the former under the head of fractures. They arise from the same causes, and whether the one or the other injury takes place in any particular instance depends on the relative strength of the ligamentous and osseous tissue; though, as Mr. Rivington has pointed out, the frequent presence of an arthrodial joint between the manubrium and gladiolus favour the occurrence of displacement in preference to fracture.* As regards the symptoms, they very much resemble those of fracture, and the resemblance is further increased by the fact that almost invariably the displacement is the same in the two forms of injury; that is to say, the upper end of the lower fragment of the bone, either in fracture or dislocation is displaced in front of the lower end of the upper fragment. (*See* page 131.)

DISLOCATION OF THE BONES OF THE PELVIS.

Dislocation of the bones of the pelvis is generally attended with fracture, and often complicated with other severe injuries, which rapidly prove fatal. Occasionally, however, simple dislocation, without fracture, may occur, and may implicate either the symphysis pubis or the sacro-iliac joint.

Dislocation at the symphysis pubis.— In these cases the interarticular cartilage is not usually torn, but is separated from the bone on one or the other side. The pubic bone may be displaced in almost any direction, and may cause injury to the urethra and

* Med.-Chir. Trans., vol. lvii., p. 101.

bladder. Great violence is necessary to produce this displacement, which is generally occasioned by falls from a height either on to the feet or the buttocks, so that the force acts on either the acetabula or tuberosities of the ischia, tending to force them asunder. There is in these cases great pain and inability to bear the weight of the body on the legs in consequence of the solution of continuity of the bony ring of the pelvis. The displacement at the pubic symphysis can generally be made out by careful digital examination.

In dislocation of the sacro-iliac joint the displacement may be partial or complete, and the innominate bone may be luxated either forwards or upwards and backwards, the latter being the more common. As in the dislocation at the symphysis pubis, so here, the interarticular cartilage is not torn through, but is severed from its attachment to one or the other bone, sometimes carrying a thin scale of bone with it. These dislocations also require great force for their production, being generally caused by falls from a height.

Symptoms.—There is deep-seated pain in the pelvis and all voluntary movement is abolished. Frequently there is compression or laceration of the nerve trunks, producing more or less complete paralysis. Mr. Skey records a case of a young man who fell from a height and dislocated his innominate bone backwards. The limb on the affected side was completely paralysed. After a week reduction was effected with pulleys, when the paralysis at once disappeared.* Frequently there is retention of urine from stretching of the urethra by the displaced bone. When dislocation takes place backwards or upwards, there is apparent, but no real shortening of the leg. The foot is everted, the crest of the ilium approximated to the ribs, and the posterior superior spine of the ilium can

* *Lancet*, vol. i., p. 31; 1864.

be felt projecting posteriorly. When dislocation takes place forwards there is an increased transverse diameter of the pelvis. The anterior superior spine of the ilium projects in front. There is in some cases slight eversion of the foot.

Treatment.—An attempt at reduction should be made in all cases by fixing the pelvis and making steady extension. Occasionally the bone will recede into its place with a very audible snap. The patient must afterwards be kept perfectly quiet on his back, with the pelvis fixed by a broad belt or bandage.*

CHAPTER IV.

DISLOCATIONS OF THE LOWER EXTREMITY

DISLOCATIONS OF THE HIP.

THE hip joint is a ball-and-socket joint, enjoying great variety and freedom of motion, which it possesses to a certain extent at the expense of its safety. Accordingly we find that this joint is more frequently dislocated than any other joint in the body, with the exception of the other large ball-and-socket joint, the shoulder. Dislocation of the hip is, nevertheless, incomparably less frequent than that of the shoulder, (1) on account of the shape of the articular surfaces, a large segment of a small sphere articulating with a deep cup-shaped cavity; (2) on account of the strong ligaments by which the bones are united, and the muscles by which it is surrounded and braced; and (3) on account of the

* *See* an interesting memoir on Dislocation of the Bones of the Pelvis, by Dr. Salleron, who records three cases; *Archives Générales de Médecine*, July and August, 1872.

fact that it is less exposed to injury than the corresponding joint of the upper extremity. The amount of violence required to produce a dislocation of the hip far exceeds that which will produce one at the shoulder, and must be very great. As giving an estimate of the relative frequency of these two injuries, it may be stated that in a considerable number of cases of dislocation of the different joints of the body, collected from various sources, fifty-eight per cent. were dislocations of the shoulder, and only five per cent. of the hip.

The accident may occur at any age; the youngest case in which it has been recorded was in a child, aged six months, by Mr. John Powdrell. The dislocation was downwards and forwards into the obturator foramen, and was caused by the child, with the chair in which it was sitting, being upset, and the child being doubled on its side over the left arm of the chair. Reduction was effected without difficulty, and the infant did well.* The oldest case in which dislocation of the hip has been recorded is given by Malgaigne. It occurred in a patient, aged eighty-five. In persons of advanced life, however, this accident rarely occurs. When any violence is applied to the hip joint, the neck of the femur more usually gives way in consequence of the changes in the structure, shape, and position of this part, which take place in old persons. In young children, also, the accident very rarely occurs, and the case recorded above must be looked upon as a very exceptional one. We may limit the period at which this accident is likely to take place to between the ages of twenty and forty-five, during which period individuals are much more exposed to the violence necessary to produce dislocation than at other times. It is also, as would naturally be expected, much more common in the male than in the female.

* *Lancet*, vol. i., p. 617; 1868.

As regards the directions in which the head of the femur may be displaced from the acetabular cavity, Mr. Bryant has practically expressed their variety when he says, "the head of the thigh bone may rest at any point around its socket." They are usually classed, for purposes of description, as occurring in four chief directions: (1) upwards and backwards, on the dorsum ilii; (2) backwards, into the sciatic notch; (3) downwards, into the obturator foramen; and (4) inwards, on to the pubes. But the head of the bone may be thrown in almost any direction from its socket, and may occupy almost any position around the acetabulum.

It is exceedingly convenient, however, for purposes of description, to accept the classification of dislocations above mentioned, and which has been employed since the days of Sir Astley Cooper; and for all practical purposes this distinction into four varieties is sufficient, and in the majority of cases the dislocation may be classed under one of these four heads. Bearing in mind, therefore, that the form of each variety of dislocation may vary, and that the head of the bone is not always in exactly the same place, we may adopt the classification of Sir Astley Cooper as practically the best.

As regards the relative frequency with which these varieties of dislocation are met with, a general idea may be obtained from 292 cases collected from various sources. Of these, 53·1 per cent. were dislocations on to the dorsum ilii; 24·3 per cent. were sciatic; 14 into the obturator foramen; and 8·6 per cent. were dislocations inwards on to the pubes.

The mechanism by which the different dislocations of the hip are produced has been the subject of considerable controversy and difference of opinion. During the last few years fresh impetus has been given to this subject by the very able paper of Mr. Morris in the

Medical and Chirurgical Transactions,* in which he endeavours to prove, from anatomical considerations, experiments on the dead body, and observation and dissection of recorded cases, the fact, which was first propounded by Fabbri,† that all dislocations of the hip, uncomplicated by fracture, are the result of forced abduction of the femur, and "that the *posterior* dislocations result when flexion and rotation inwards accompany abduction, and the *anterior* when extension with rotation outwards accompany abduction, while the *downward* or thyroid variety occurs during abduction unaccompanied by rotation." So that the situation of the head of the bone in a dislocation is determined by the degree of flexion or extension, and of inward or outward rotation of the thigh at the moment of luxation; the sciatic dislocation, for instance, requiring a greater degree of flexion and rotation inwards than is required to produce the dorsal dislocation.

Mr. Holmes Coote also holds the same view. He says: "There is but one primary dislocation of the femur at the hip joint, namely, that into the foramen ovale, or downwards and inwards, though, possibly among primary dislocations, we should include dislocations of the head of the femur downwards and backwards as well as inwards. The other forms (namely, those on the dorsum ilii, the ischiatic notch, and on the pubes) are secondary, dependent either on muscular action or on the continuance of the dislocating force."

Professor Roser, in 1857, enunciates the same opinion. He says: "The head of a dislocated bone is not, as a general rule, found in the primary position which was given to it by the force applied, and the

* Med.-Chir. Trans., vol. lx., p. 161.
† *British Medical Journal*, Jan. 11, 1868.
‡ Ibid., vol. i., Jan. 11, 1868.

reduction process must have for its object, first, to restore the dislocated bone to its primary position, and thence to effect its return."

There can be no doubt that this is the simplest form of explanation which can be adopted, and Mr. Morris has brought forward some cogent arguments, and has so ably reasoned his case, that he almost carries conviction in the minds of his readers. But, as Mr. Rivington justly observes, "the true history of dislocations of the hip joint can scarcely be written only from anatomy and experiments on the dead subject, but from these in combination with faithful records of a large number of cases."

There is no doubt that in abduction of the limb the greatest strain is thrown on the capsular ligament; that when the thigh is adducted the head of the bone impinges on the strongest and deepest part of the acetabular cavity, and very little strain has to be borne by the capsular ligament; but that when the thigh is abducted, owing to the shallowness of the lower and inner part of the cotyloid cavity, the head of the bone bulges over its margin, and a severe strain is thrown upon the capsular ligament at its lower and inner part. And, moreover, anatomy undoubtedly teaches us that this is the weakest part of this ligament; that the capsule is thick and strong behind and above, and especially in front, but that it is thin and comparatively weak below and internally, at that part, in fact, where the head of the bone presses during abduction, especially if combined with flexion and inward rotation. In consequence of this condition it can be proved experimentally that dislocation on the dead subject can only be produced by tearing this weak part of the ligament, that is to say, by abduction of the limb, and that no force which can be applied

* *Brit. and For. Med.-Chir. Rev.*, vol. ii., p. 546; 1857.
† *Lancet*, vol. ii., p. 321; 1878.

is sufficient to produce dislocation in any other way. These arguments, however, do not seem to me to be quite conclusive in the light of certain recorded cases; and therefore, though I am inclined to go a long way with Mr. Morris, and say that, in my opinion, most dislocations are produced in the manner he points out, I cannot go so far as to say that they cannot occur in a direct way without fracture of the acetabulum. In fact, I think there are certain proofs that a dislocation may be produced in this way. For instance, the case recorded by Sir William MacCormac in the St. Thomas's Hospital Reports, plainly proves this point. Here the head of the femur was clearly forced directly backwards through a rent in the upper and back part of the capsular ligament. Again, Mr. Stephen Paget recently exhibited a specimen of dislocation of the femur backwards at the Pathological Society, in which he believed that the dislocation was the result of direct violence;* and other cases of the same kind might be cited.

Mr. Eve† takes the opposite side of the question, and inclines rather to the opinion, originally enforced by Sir Astley Cooper, that most of the dislocations backwards are direct, that the femur at the time of the accident is flexed and adducted, and that the head of the bone is forced directly backwards through the capsule, and that "indirect dorsal dislocations by no means so greatly preponderate over direct dislocations as Mr. Morris maintains."

1. **Dislocation on to the dorsum ilii.**—This dislocation, whether caused in a direct or indirect manner, is certainly the most common as regards the ultimate destination of the head of the bone, constituting more than one-half of the total number of dislocations of the hip. The head of the bone in this

* *Lancet*, vol. i., p. 520; 1885.
† Med.-Chir. Trans., vol. lxiii., p. 51.

variety of dislocation generally rests on the dorsum of the ilium, just above the small facet which marks the origin of the reflected tendon of the rectus muscle (Fig. 74); but its position varies, and the height to which it ascends depends mainly upon the nature of the dislocating force, and the amount of laceration of the capsule and external rotator muscles. It is always situated above the obturator internus muscle, while the sciatic form is below it, and it is by the relative position of the head of the bone to this muscle that Bigelow distinguished the two forms of dislocation; describing them as dislocation backwards, "above or below" the obturator internus. They appear both to be produced in the same way, and the dislocation under consideration must be regarded as a more advanced grade of the sciatic form.

Fig. 74.—Dislocation on to the Dorsum of the Ilium.

The head of the bone is resting on the dorsum ilii, *above* the obturator internus muscle.

Causes.—One of the most frequent ways in which a dislocation of the hip backwards on to the dorsum ilii is produced is, as Sir Astley Cooper has pointed out, in consequence of the person falling whilst carrying a heavy weight on his shoulder, or from a severe blow under the same circumstances. In these cases the limb would in all probability be flexed and abducted, in order to enable the patient to bear the weight by bending the body forwards and widely

separating the feet so as to give a wider basis of support. Hence it is easy to understand that the pressure is made on the weakest part of the capsule and the head of the bone primarily displaced downwards, in the manner demonstrated by Mr. Morris. Another frequent way in which dislocations on to the dorsum ilii are produced is by falls from a height upon the bent knee or even the foot.

Other causes are heavy weights, such as a mass of earth or masonry, falling on the back whilst the body is bent forwards in the stooping position. Slipping and falling to the injured side whilst wrestling, or falls from horseback when the horse rears and falls backwards or on his side, under all which circumstances probably abduction, to a greater or less extent, would be present.

The ligamentum teres is always torn in these dislocations, or else separated from its attachment to the dimple on the head of the femur. The capsular ligament is also torn. If the dislocation is produced in the ordinary way, while the limb is in the position of abduction, the rent in the capsule is at its posterior and lower part. "The rupture is jagged and irregular, but will be found to extend more or less directly from near the shallow rim of the acetabulum, across the thin portion of the capsule to the femur near the small trochanter, and then to run along the back of the ligament close to its attachment to the neck of the bone" (Morris). When the dislocation is direct, the rent will be found running across the back of the capsule, or, what is moie common, the capsular ligament will be found more or less intact, and the upper and back part of the acetabulum will be fractured. The ilio-femoral ligament is not torn. The various muscles around the joint, especially the small external rotators, are frequently injured, sometimes being lacerated, somctimes

bruised. The glutei and pectineus may also be ruptured in part, and the psoas and iliacus are greatly stretched. The great sciatic nerve may be compressed between the femoral neck and the rotator muscles, and is sometimes much contused.

Symptoms.—In this form of dislocation there is well marked and palpable distortion about the hip. The buttock is somewhat prominent, broader and flatter than natural, and the upper part of the thigh is enlarged, so as to give an appearance of widening in this situation. The trochanter is less prominent and nearer to the anterior superior spinous process of the ilium than in its natural position. The head of the bone can usually be felt beneath the glutei muscles in its new position, and can be felt to move if the limb is flexed. There is considerable shortening, often from two to three inches, owing to the fact that the head of the bone is on a higher level than in its natural position, and the line from the condyles of the femur to the anterior superior spine of the ilium is lessened by the backward displacement of the bone. The thigh is flexed, rotated inwards, and adducted so that the axis of the bone is directed across the lower third of the sound thigh. The knee is semiflexed, and in consequence of the rotation inwards the foot is inverted and the ball of the great toe rests against the front of the ankle joint or on the instep of the sound limb (Fig. 75). The movements of the thigh are greatly impaired, voluntary movement is quite abolished, and also all passive movements in the direction of extension, abduction or eversion; some slight amount of flexion, adduction, and inversion is permitted. The vessels in the groin may be noticed to have lost their support from behind, so that on pressing on them with the fingers they can be felt to be unsupported and the existence of a hollow behind them be easily perceived. This is an important sign,

to which Mr. Morris has drawn attention, and is a valuable aid to diagnosis.

This gentleman states that in one case he was able to define the outline of the acetabulum by making firm pressure along the line of the femoral vessels, and the "vessels themselves could be made to dip a long way back."

Fig. 75.—Dislocation of the Femur on to the Dorsum Ilii.

The illustration represents the deformity which is produced in dislocation of the head of the femur on to the dorsum of the ilium. (After Astley Cooper.)

The diagnosis of this injury is generally easy, especially if the head of the bone is high on the dorsum of the ilium, so that it can be felt through the large muscles of the buttock. It may be diagnosed from fracture of the neck of the femur by the fixed position of the limb, by the inversion, and by the absence of crepitus.

In some cases, however, of impacted fracture of the neck the limb is inverted, and this circumstance, combined with the absence of crepitus, might lead to an error in diagnosis.

The position of the great trochanter and the head

of the bone, if it can be felt, on the dorsum, would be sufficient to render such an error improbable.

Treatment.—Very great difficulty is sometimes experienced in the reduction of this and other forms of dislocation at the hip joint, and surgeons have not been agreed as to the cause of these difficulties.

Sir Astley Cooper believed and taught that the great obstacle to reduction was the resistance of the muscles, and that the capsular ligament was generally too much torn to offer any impediment. He therefore attempted reduction by applying traction which would overcome the supposed muscular resistance very much in the line of the dislocated femur. In this he was followed by Chassaignac (who recognised no other impediment to reduction than muscular contraction), and many others. Of later years, however, the opinion has been gaining ground that the obstacle to reduction is to be found in the resistance of the untorn part of the capsular ligament, and especially of that part which is known as the "ilio-femoral" ligament, and which is not torn in dislocations, except perhaps occasionally as the result of very extreme violence. This view has been strongly advocated by Bigelow, who describes the ilio-femoral ligament as resembling an inverted Y, the fibres bifurcating below into two limbs, at its attachment to the anterior intertrochanteric line. This gentleman states that this ligament and the portion of capsule untorn, which is immediately adjacent, are chiefly responsible, not only for the principal symptoms of dislocation, but also are the main obstacle to reduction, and that the essence of success in reduction depends upon the thorough relaxation of this ligamentous structure.

If this view is correct, it is clear that extension in the axis of the thigh can only succeed in effecting reduction by lacerating or severely stretching this

untorn part of the capsular ligament, and that in order to succeed without this it is necessary that these ligaments should be relaxed by flexion of the thigh on the pelvis before any traction is made. This plan was adopted by Mr. Quain many years ago in a case of dislocation of the hip, in which, by making his traction with the thigh flexed at right angles to the trunk, he was enabled speedily to effect reduction.

The head of the thigh bone when dislocated may be restored to its proper position by "manipulation" or by "extension."

By manipulation.—By this means almost all recent dislocations of the hip can be reduced, and this without any great expenditure of force, and the plan should always be first adopted before recourse is had to any severer measures. The object of this plan of treatment is to endeavour by certain movements of the limb to make the head of the bone retrace the same steps which it has taken, and thus induce it to return through the same opening in the capsule through which it has forced its way. There can be no doubt that this plan is far more scientific and much to be preferred to the old plan of reduction by means of extension with the pulleys or otherwise, where an endeavour was made to overcome the displacement by sheer force, an endeavour which must be accompanied by a certain amount of damage to the tissues around the joint.

Bigelow considers that "the flexion method is the only rational one, and that pulleys are practically obsolete." Whether the latter part of this assertion may be regarded as true or not, it is unquestionably the proper treatment to attempt, at all events in the first instance, the reduction of any dislocation of the hip by means of manipulation, and in most recent cases this plan of treatment, if properly conducted, will be found to succeed, and also in many

instances of old-standing dislocation, and this even after the pulleys have failed to accomplish their object.

In all cases the patient should first be thoroughly anæsthetised. Having been placed on his back, preferably on the floor, as it gives the surgeon a greater command over the limb, the leg is to be first of all flexed on the thigh, so as to relax the hamstring muscles and disengage the sciatic nerve, which may be locked between the head of the bone and surrounding structures. The thigh is now to be flexed on the abdomen, and this flexion is to be carried to its extreme limit; the knee being somewhat adducted and brought well over the middle line of the body.

The object of this flexion, on which the successful issue of the operation in a great measure depends, is to thoroughly relax the untorn part of the capsule, and especially the ilio-femoral ligament, and to allow the head of the bone to retrace its course along the back of the acetabulum.

This position of extreme flexion should be maintained for a few moments, the surgeon grasping the flexed knee in both hands and pressing it downwards by the weight of his body towards the abdomen of the patient. He then, still keeping up firm pressure, abducts the flexed limb to its fullest extent. By this means he forces the head of the bone inwards towards the lower edge and shallowest part of the acetabulum and into the situation of the rent in the capsule, through which the head of the bone is intended to return. By these two manœuvres the head of the femur has been brought into the position most favourable for reduction, that is to say, just below and internal to the cotyloid cavity and opposite the part of the capsule which has been torn in the primary displacement of the bone. The return of the head of the femur is now to be accomplished

by rotating the whole bone outwards and suddenly bringing it down into the extended position. The first of the two movements turns the head of the bone through the opening in the capsule, and the second causes it to recede into the cavity of the acetabulum.

The process may be summed up in the following terse form: "Bend up, roll out, turn out, and extend."

Some authors believe that rotation *inwards* answers equally as well as rotation outwards, and Bigelow regards flexion as the most important movement, compared with which the rest of the manipulation is of secondary importance; while Ponteau and Després consider the "abduction" to be the essential part of the manœuvre. If this plan of manipulation should not succeed, the surgeon may flex the thigh on the pelvis, and having abducted it, with his fore-arm placed under the bent knee of the patient and his foot on the pelvis, may pull the head of the bone directly upwards into its socket. Mr. Kelly speaks highly of this plan, and has somewhat elaborated its details.* "Three strong screw hooks are inserted into the floor close to the perinæum and each ilium of the patient, and to these hooks he is secured by a strong bandage or rope. The injured thigh is flexed at right angles to the patient's body; the foot and lower extremity of the tibia are placed against the perinæum of the surgeon, who, bending forward with his knees slightly flexed, passes his fore-arms behind the patient's knee and grasps his elbows. He is now in the best position to accomplish the reduction (Fig. 76). With this object he exerts his strength to draw the femur upwards, which action is generally sufficient to effect it; but, when necessary, circumduction may be combined with extension, as the surgeon, while maintaining

* *Dublin Journal of Medical Science*, October, 1882.

traction, sways his body towards the patient's uninjured side, then towards his head, then outwards, and stepping backwards he lays with a sweep the injured limb by its fellow, and thus the dislocation is reduced." This proceeding may be reversed by suspending the patient's bent knee over a bar, so that the buttocks are raised some few inches from the ground. The

Fig. 76.—Reduction of Dislocation of the Hip.

The illustration shows the method recommended by Mr. Kelly of reducing dislocations of the thigh bone backwards. (After Kelly.)

weight of the body, combined if necessary with pressure downwards on the pelvis, may thus succeed in reducing the dislocation.

2. **Extension.**—When manipulation does not succeed in effecting reduction, recourse must be had to extension by means of pulleys. The patient is to be laid on his back and the pelvis fixed, by a perineal band, to a staple attached to some fixed object behind the patient's head. The extending force is made in a direction across the lower third of the opposite thigh (Fig. 77). This is the plan originally

recommended by Sir Astley Cooper, but it seems clear that if it is adopted in its entirety it must endanger the ilio-femoral ligament, and that reduction will scarcely be accomplished without rupture of this and the adjacent portion of the capsular ligament, and it is better therefore to place the patient on his sound thigh, as Sir A. Cooper recommends in the sciatic dislocation, and with the injured thigh flexed on the abdomen to make extension at right angles to the trunk. By this means the ilio-femoral ligament will

Fig. 77.—Reduction of Dislocation of the Hip by pulleys.

The illustration shows the method recommended by Sir Astley Cooper of reducing dislocations of the femur on to the dorsum ilii by the application of pulleys. (After Astley Cooper.)

be relaxed, and reduction of the dislocation effected with a far less expenditure of force, and without the same probability of injury to the structures surrounding the joint.

2. **Dislocation backwards.**—This form of luxation is generally termed "dislocation into the sciatic notch;" but perhaps it would be better to call it "dislocation *near* the sciatic notch, since at present there is no evidence, from actual dissection, that the head of the bone is ever really actually driven *into* the notch. In fact, Professor Bigelow denies that such a dislocation ever occurs, and makes no distinction between this form of dislocation and that on to

the dorsum ilii, beyond defining their relative positions with regard to the tendon of the obturator internus muscle. He differentiates the two by stating that in the dorsal luxation the head of the femur is above the obturator internus tendon, while in the so-called sciatic form it is below it.

In this dislocation the head of the bone may rest on any part of the posterior surface of the ischium, between the edge of the acetabulum and the margin of the great sacro-sciatic notch (Fig. 78). Frequently it rests just on the margin of the notch, but may be carried farther back and rest on the structures passing through the foramen. Sometimes it may be situated on a slightly lower level, and then rests on the back of the spine of the ischium, between the greater and lesser sacro-sciatic notches, and this probably is the most usual position for the head of the bone to be placed. Again, in other instances, the head may be found at a still lower level, resting against the tuberosity of the ischium, opposite the smaller sacro-sciatic foramen. Fabbri describes two forms of this dislocation, one he calls the "ischio-sciatic," where the head of the bone rests on the quadrilateral posterior

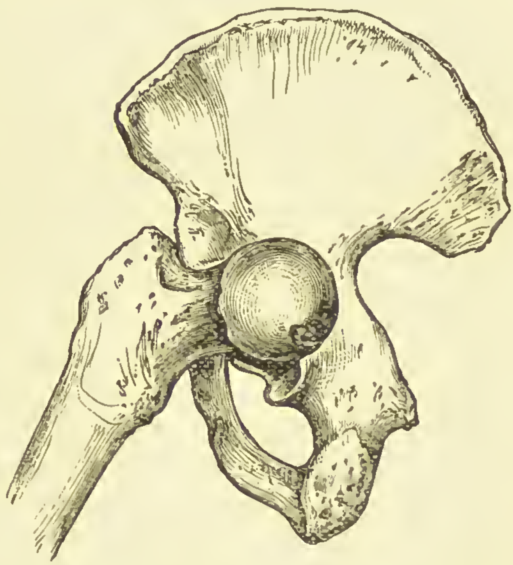


Fig. 78.—Dislocation backwards of the Head of the Femur.

The head of the femur rests on the posterior surface of the ischium, between the edge of the acetabulum and the margin of the great sacro-sciatic notch.

surface of the ischium, and the other he calls the "sacro-sciatic," where the head of the bone rests on the sciatic notch. The former of these would correspond to Bigelow's "posterior dislocation below the tendon of the obturator internus." The latter would correspond to the typical "dislocation into the sciatic notch," described by Sir Astley Cooper and others.

Causes.—There can be no doubt that, as regards the causes which produce this form of dislocation, it must be regarded as merely a modification of the dorsal displacement, the injury being produced by identically the same causes, and in precisely the same way, the occurrence of a dorsal or sciatic displacement merely depending upon the amount of flexion and inward rotation of the thigh at the moment that dislocation takes place; that is to say, at the time the accident occurs the limb is in a condition of abduction, and the head of the femur, partially protruded from the shallow part of the acetabulum, presses against the thin and weak part of the capsular ligament. From the effects of the injury this gives way, and the head of the bone is primarily displaced downwards. In consequence of the flexion and inward rotation of the thigh being extreme, the head of the bone, instead of finding its way backwards and upwards on to the dorsum of the ilium, is forced more directly backwards, and a sciatic dislocation is produced. In this way it seems probable that most of the so-called "dislocations into the sciatic notch" are produced; the *direct* dislocation backwards, without fracture of the acetabulum, probably never occurring. M. Tillaux takes a somewhat different view as to the manner in which both these backward dislocations are produced. He believes that when the limb is abducted, flexed, and rotated inwards, the head of the bone rests against the posterior part of the capsule, and that in every dislocation backwards this ligament

must be torn away from the lower and posterior part of the acetabulum. This portion of the ligament being torn, an *incomplete* luxation takes place, the head of the bone resting on the margin of the acetabulum, and the rest of the capsule remaining entire. This incomplete dislocation M. Tillaux believes to be a necessary prelude to the complete luxation which is produced by a further laceration of the capsular ligament, the difference in the eventual position of the head of the bone depending upon the part of the ligament which remains untorn. When the anterior part of the capsule gives way, leaving only the upper and back part unruptured, a sciatic dislocation results. When, on the other hand, the upper and back part is torn, and the anterior portion remains intact, the dislocation will be on to the dorsum ilii.*

Symptoms.—The signs by which the sciatic dislocation is characterised are very similar to those of the iliac dislocation, the main difference being that they are less pronounced and less marked. There is distortion and flattening about the hip, but not in so great a degree as in the dorsal dislocation; nor is the trochanter so much displaced; it is usually noted to be a little above and some distance behind its normal situation. There is also less shortening, usually not more than half an inch, or at most an inch. In consequence, however, of the inclination of the trunk to the sound side, the shortening often appears to be very considerable, the knee being often two or three inches above the natural level; but on actual measurement from the anterior superior spinous process of the ilium to the malleoli the actual amount will be found to be slight. The thigh is flexed, rotated inwards and adducted, though to a less extent than in the dorsal

* "Recherches experimentales et cliniques sur le Mécanisme de la Production de Luxations coxo-fémorales en arrière," 1876.

dislocation,* so that the ball of the great toe rests on the great toe of the sound foot (Fig. 79).† The axis of the femur is directed across the sound knee, and it is on this symptom that Mr. Erichsen principally depends in arriving at a differential diagnosis between the two forms of dislocation. "When the head of the bone rests in the sciatic notch, the axis of the femur is directed to the opposite knee, whereas, when the head of the bone is lodged on the dorsum ilii, the axis of the limb is directed across the lower part of the sound thigh." In some cases the head of the femur can hardly, if at all, be felt, in others it can be perceived without difficulty. This difference probably depends upon its position, and also on the amount of swelling, and the thickness of its gluteal covering. If the head of the bone lies in

Fig. 79.—Dislocation of the Femur backwards.

The illustration represents the deformity which is produced in dislocation of the head of the femur backwards. (After Sir Astley Cooper.)

* Bigelow says that the inversion is *greater* in the dislocation "below the tendon."

† Mr. Quain has recorded two cases in which the limb was abducted, though rotated inwards. In one of the cases the neck was strapped down by the great sciatic nerve, which may explain the anomalous position (Med.-Chir. Trans., vol. xxxi.).

the sciatic notch, resting on the soft structures which emerge from it, probably it will not be easily felt. If, on the other hand, it rests on the posterior surface of the ischium, or its spine, there will be little difficulty in defining it. Certainly, in a case which I had an opportunity of examining a few days ago, the head of the bone was distinctly to be perceived, and could be felt to move with the motions of the limb. Active movement, and almost all passive movement, is abolished, flexion being the only motion that is permitted.

Treatment. — The methods of reducing this dislocation are much the same as those which are employed for the dorsal luxation. In most cases it will be found that the head of the bone can be returned to its natural situation by manipulation, and extension with the pulleys will rarely be required. If the theory is correct that these two backward dislocations are produced in the same way, and the only difference in the eventual position of the head of the bone depends upon the amount of flexion and inward rotation at the moment of displacement, it is clear that the same manœuvre ought to accomplish the reduction in either case. And such is the fact, and hence this theory appears to gain additional confirmation from the results of treatment, since those movements of the limb which force the head of the bone to pursue a definite course are successful in effecting reduction in either instance. By flexing the thigh on the pelvis, abducting and rotating outwards, the head of the bone is made to retrace its steps, just as in the dorsal dislocation, and it is without difficulty, or any great expenditure of force, returned to its socket.

The method of reduction by extension with the pulleys is very much the same as in the dorsal dislocation. Sir Astley Cooper recommends that the patient should be laid on his sound side, instead of

his back, and extension made across the middle of the opposite thigh (Fig. 80); but he appears to have found great difficulty in reducing this dislocation by extension. He advises, in case there is any difficulty, which possibly may arise from the head of the bone hitching against the margin of the acetabulum, to raise it up by means of a round towel placed under the upper part of the thigh and over the shoulders of an assistant, and by this means to lift the head of the bone

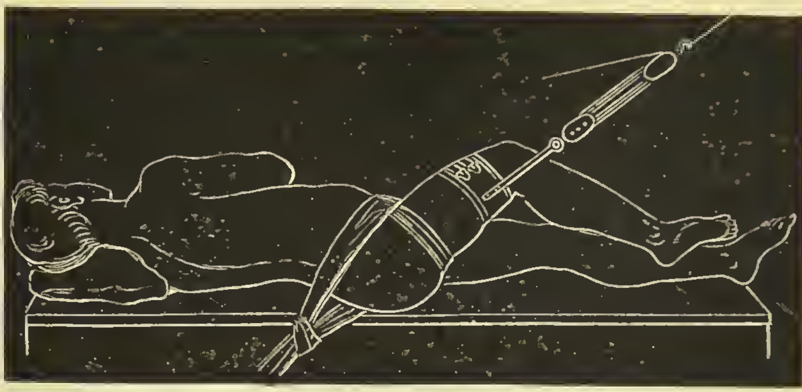


Fig. 80.—Reduction of Dislocation of the Hip backwards by pulleys.
The illustration shows the method recommended by Sir Astley Cooper of reducing dislocations of the femur backwards by the application of pulleys. (After Astley Cooper.)

into its place. The essential part of the treatment of this dislocation, as in the one on to the dorsum, by means of extension, is to make it with the limb in as complete a degree of flexion as possible, in order to relax as much as may be the ilio-femoral band; and, therefore, even a greater degree of flexion than that recommended by Sir Astley Cooper will be found to be advantageous, and will ensure a greater probability of success.

3. **Dislocation downwards, into the obturator foramen.**—It has been stated that in all probability most dislocations are primarily displacements downwards, and that the head of the bone, having

thus been first luxated from its socket, then changes its position, passing upwards, either behind or in front of the acetabulum, according to the position of the limb. The reason why the head of the bone does not remain in the position in which it is primarily displaced, and thus constitute the downward displacement into the obturator foramen as the most common form of the accident, is because the initial violence and the action of the muscles force the head of the bone to quit its new position and assume that in which it is eventually found.

It may, therefore, be asserted that the displacement downwards, which we are now describing, is the one which *almost invariably* takes place in the first instance (page 424), and may therefore be regarded as the one primary dislocation of the hip, but that, for the reasons above mentioned, the head of the bone does not remain in this position.

If, however, in the words of Mr. Morris, "the dislocation is neither accompanied nor followed by rotation, or fixed flexion or extension, the head of the femur will remain below the acetabulum and will occupy the foramen ovale," and a dislocation downwards, or "obturator dislocation," be the result.

Causes.—All authors appear to be agreed as to the way in which this dislocation into the obturator foramen is produced, namely, by violent abduction of the thigh. When the thigh is abducted, the head of the bone bulges over the shallow part of the acetabular rim by the cotyloid notch and presses against the thin and weak part of the capsular ligament, which gives way. The dislocation can be artificially produced on the dead subject by forcibly abducting the thigh until the ligaments are heard to give way, when the head of the bone will be at once displaced, and if no further movements are applied to the limb, owing to the fact that there is no

active muscular action to cause any alteration in the position of the head of the bone, it will be found to remain resting on the obturator membrane, and this form of dislocation will be produced. Thus it follows that any injury whereby the thighs are widely separated from each other would produce this dislocation.

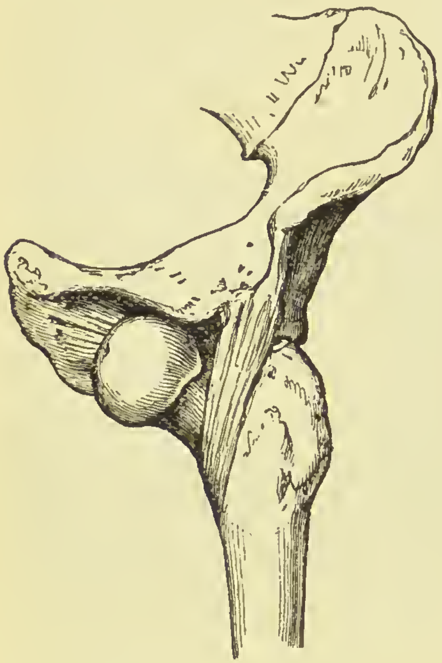


Fig. 81.—Dislocation of the Femur downwards into the Obturator Foramen.

The head of the bone rests on the obturator foramen, on the obturator externus muscle.

Morris records a case, mentioned to him by Mr. Critchett, which remarkably well illustrates the manner in which this accident may be caused. In this case both hips were displaced into the thyroid foramen in a man who was stepping from one steamer to another just as they were pushing apart. So, again, in a case recorded by Bryant, it was caused by violent abduction of the thigh in a girl who was stepping from an omnibus in motion. Falling from a height and striking the ground with the feet widely apart is also a common cause of the accident.

When this form of dislocation takes place, the head of the bone is thrown so much inwards that it is generally in contact with the inner margin of the obturator foramen, resting on the obturator externus muscle (Fig. 81). Sometimes it is thrown even farther

inwards than this, and lying internal to the foramen, rests on the rami of the pubes and ischium, and can be easily felt in the perinæum.

In this, as in the other dislocations, the ligamentum teres is always torn, or rather, as Professor Humphrey has pointed out, is separated from its dimple in the head of the femur.

Symptoms.—The signs by which we recognise this injury are well marked. There is considerable deformity about the hip, with an appearance of flattening. The trochanter is not so prominent as it ought to be, and generally appears to be completely absent, and its position is replaced by a depression. If it can be felt it will be found to be considerably nearer the median line than normal. There is also a depression below the middle of Poupart's ligament; and behind, the fold of the buttock will be found to be on a considerably lower level than on the sound side. If the patient is in the erect position, the body will be bent forward, owing to the psoas and iliacus muscles being put on the stretch, and will be tilted over to the injured side, from obliquity of the pelvis, thus giving an appearance of very considerable lengthening of the limb. The limb is also abducted and advanced in front of the other (Fig. 82). The toes are generally pointed straight forwards, though perhaps there may be slight eversion from tension of the adductor muscles. If the patient is made to lie on his back, the thigh will be somewhat flexed on the pelvis and the leg on the thigh, owing to the hamstring muscles being put on the stretch; so that the bent knee is incapable of extension. The knee is widely separated from the other and cannot be approximated without causing great pain. There is apparently very great lengthening. This is, in some measure, due to the tilting over of the pelvis to the affected side, but there is, in addition to this, in most cases at all

events, some slight actual lengthening. But Mr. Holmes and Mr. Rivington have both recorded cases in which there could not be found to be, after the most careful measurement, any actual increase in the length of the limb. Dr. R. Adams has pointed out, as a sign of this dislocation, that the adductor muscles, which are stretched and elongated, form a "round prominent line which extends from the pubes to the middle of the thigh." * Fabbri has described the same sign as a "tensé cord parallel to the axis of the thigh, beginning at the spine of the pubes, widening as it descends, and disappearing in the middle of the thigh." The facility with which the head of the bone can be felt varies with its position. If it has been thrown so far inwards as to rest on the rami of the pubes and ischium, it can easily be felt in the perinæum, and even the dimple on it can be detected beneath the stretched skin; if it rests on the inner side of the obturator foramen, in contact with the

Fig. 82.—Dislocation of the Femur downwards into the Obturator Foramen.

The illustration represents the deformity which is produced in dislocation of the head of the femur downwards into the obturator foramen. (After Astley Cooper.)

* "Cyclopædia of Anatomy," vol ii., p. 822.

junction of the rami of the pubes and ischium, it can generally be felt at the inner part of the thigh, towards the perinæum. Sometimes, however, the head of the bone is only carried a little way inwards and rests on the outer part of the obturator membrane, or even on the groove between the acetabulum and tuberosity of the ischium. Under these circumstances the head of the bone cannot be distinctly felt through the muscles. The amount of movement permitted in this dislocation is very limited, and any attempt at motion is attended with great pain. A certain amount of passive flexion may be performed by the surgeon, and the patient may even be able to accomplish a very slight amount of this movement by his own efforts; but any attempt at extension will be attended with severe pain and cannot be induced without using considerable force.

Sédillot has pointed out an interesting point in connection with these luxations into the obturator foramen; viz. that patients in whom the dislocation has been allowed to remain unreduced can walk without pain and with very little difficulty.*

Treatment.—Various plans have been advocated for reducing this dislocation. It will generally be found, however, that manipulation, after the patient has been thoroughly anæsthetised, will succeed in effecting reduction. The following is probably the best plan of conducting manipulation. The patient is laid on his back on the floor, and the surgeon, standing over him, grasps the ankle with one hand and the knee with the other, and having acutely flexed the leg on the thigh and relaxed the untorn part of the capsule and ilio-femoral ligament by flexing the thigh to a right angle with the pelvis, he disengages the head of the femur by slightly abducting the limb. He then rotates the thigh strongly inwards, and at the same

* *Lancet*, vol. ii., p. 219; 1861.

time adducting it he carries the knee down to the floor by a movement of extension, and so turns the head of the bone back into its socket. The ilio-femoral ligament which is wound round the neck of the bone by the rotation, thus acts as a fulcrum during extension, and so prizes the head of the bone upwards and outwards into its natural position. Other surgeons prefer, after the thigh has been flexed on the pelvis, to circumduct inwards so as to further relax the untorn part of the capsular ligament and disengage the head of the bone and then to rotate *outwards*, at the same time extending the thigh. Both plans appear to succeed, and it will sometimes be found that when the one plan has failed, the other will be successful in effecting reduction. Both measures should therefore be fairly tried before the attempt to effect reduction by manipulation is abandoned.

Other plans, by combining extension with manipulation, have occasionally been adopted with success. Thus, after flexing the thigh, the head of the bone has been drawn outwards by means of a round towel passed around the upper part of the thigh, or has been forced outwards by placing the patient with his legs on either side of a bed-post so that it shall press against the upper and inner part of the injured thigh, and pulling the ankle inwards. By this means the post, acting as a fulcrum, forces the head of the bone outwards. Mr. Kelly has proposed a somewhat similar plan of proceeding by adopting a modification of that which he has suggested for dislocations of the shoulder joint. The patient is placed on his back on a bed or table of such an elevation that his pelvis is nearly as high as the trochanter of the surgeon. A bandage, passed round the pelvis and secured on the side of the table or bed farthest from the dislocation, affords efficient counter-extension. The surgeon, with his face directed towards the dislocated joint, stands

on the inner side of the injured limb, with his trochanter pressed firmly against the femur; bending the leg behind his back he grasps the ankle with the corresponding hand and is in the position to effect the reduction. He now rotates or turns his body away from the patient, thus making traction on the femur in the most favourable direction, and at the same time presses its head towards the acetabulum.*

Mr. Holmes states that in one case, when manipulation had failed, he succeeded in effecting reduction by flexing the limb and dragging the head upwards and outwards into its socket. Standing over his patient, whose pelvis was steadied by assistants, Mr. Holmes "placed his right foot on the horizontal ramus of the pubes and dragged the flexed thigh directly upwards towards the acetabulum, rotating and jerking it in order to disengage the head from any intervening obstacles and lift it over the brim of the acetabulum. After about a minute of this manipulation the head returned into the cavity." †

Reduction by extension with pulleys must be conducted on the plan advocated by Sir Astley Cooper, which is as follows: counter-extension is made by a girth or belt, which is made to encircle the pelvis and is fixed to a staple in the wall on the patient's sound side. A second girth is placed round the upper part of the injured thigh, and passed under the pelvic girth to prevent it slipping. To this are attached the pulleys, which are fixed to a staple in the wall on the same side as the injured limb and somewhat behind his head. Extension is now made gradually with the pulleys, which will draw the head of the bone upwards and outwards. The surgeon at the same time passes his hand beneath the leg of the sound side, and grasping

* *Dublin Journal of Medical Sciences,* Oct., 1882.
† "Principle and Practice of Surgery," p. 306. 4th ed.

the ankle of the dislocated limb draws it across the middle line of the body (Fig. 83).

Sir Astley Cooper states that in using the pulleys

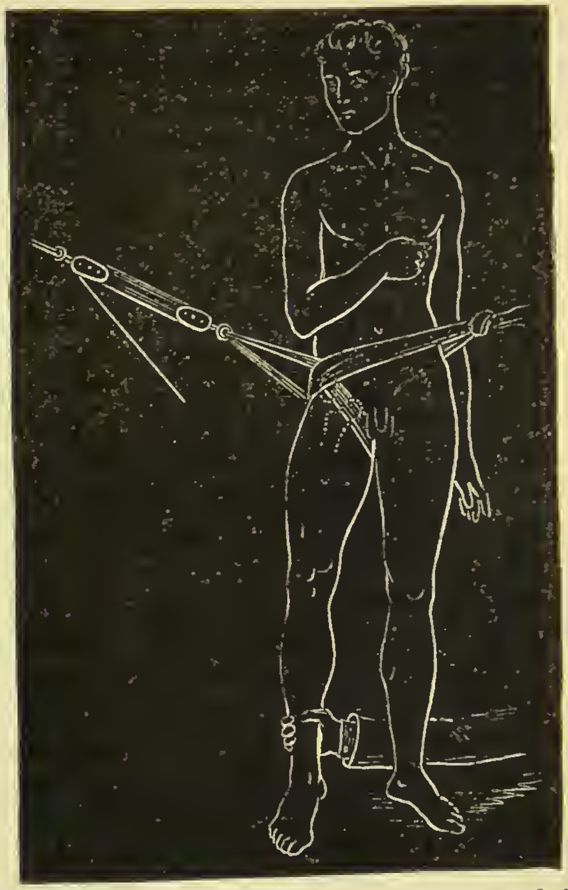


Fig. 83.—Reduction of Dislocation of the Hip downwards by pulleys.

The illustration shows the method recommended by Sir Astley Cooper of reducing dislocations of the femur downwards into the obturator foramen by the application of pulleys. (After Astley Cooper.)

great care must be taken not to "advance the leg in any considerable degree, otherwise the head of the thigh bone will be forced behind the acetabulum into the ischiatic notch." And Bigelow states that the same thing may occur during manipulation, but

regards it in rather a favourable light; and recommends, if any difficulty occurs in effecting reduction by manipulation, to "convert the thyroid into a dorsal dislocation," and then reduce by the method recommended for this form of displacement.

Dislocation on to the pubes.—This, of all the forms of dislocation of the hip, is probably the most uncommon. Nevertheless, Malgaigne states that in his experience it is not so rare as dislocation downwards into the obturator foramen. The same view is held by Fergusson and Chelius.

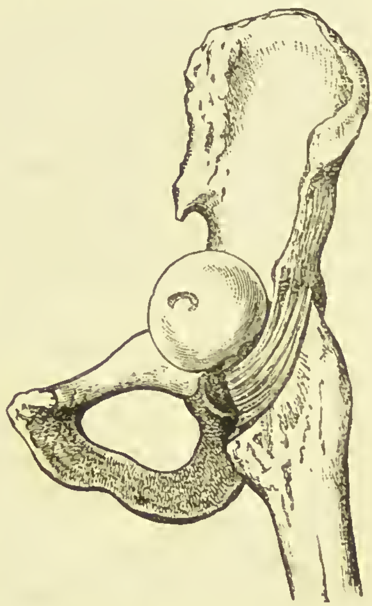


Fig. 84.—Dislocation of the Femur on to the Pubes.

The head of the bone rests on the point of junction of the horizontal ramus of the pubes with the ilium, just internal to its anterior inferior spinous process.

In the pubic dislocation the position which the head of the bone assumes varies very much. The most common situation in which it is found is resting on the point of junction of the horizontal ramus of the pubes with the ilium, just internal to the anterior inferior spinous process (Fig. 84). Sometimes the head is displaced more inwards, and rests on the triangular surface which gives origin to the pectineus muscle, even in some cases being directed so far inwards as to be in contact with the spine of the pubes. Many of the cases of so-called pubic dislocations are not luxations on to the pubes at all. Thus, Mr. Cadge, of Norwich, describes the dissection of an old unreduced dislocation, which was quoted by Sir Astley Cooper himself as a dislocation on to the pubes, in which the

head of the bone was found lying in the notch between the anterior superior and inferior spinous processes of the ilium. Again, in some cases which have been described as pubic dislocations the head of the bone has been found lying not *on* the pubes, but in front of this bone, a little to the inner side of the anterior inferior spinous process of the ilium. This latter displacement is now generally regarded as an anomalous dislocation, and is described as the "subspinous" dislocation of the head of the bone. Hence it follows, that in many of these luxations of the thigh bone forwards and upwards, the term "dislocation on to the pubes" is a misnomer, and Mr. Cadge has proposed for them the appellation "dislocations under the crural arch."

Malgaigne, on account of the frequency with which the head of the bone is found in the first position enumerated, that is, on the bone at the point of junction of the pubes and ilium, has suggested the term "ilio-pubic dislocation," and this is adopted by some authors.

Causes.—This dislocation is probably always produced while the limb is in the position of abduction, and the head of the bone is primarily displaced downwards. After this primary displacement has taken place, the limb at the time of its occurrence being in a condition of extension and outward rotation, the head of the bone is forced by the initial violence, and perhaps by the action of the muscles, upwards and forwards "under the crural arch." Thus this form of dislocation is likely to be produced by a patient, in walking or running, putting his foot in some hollow or inequality of the ground, and throwing his body violently backwards in order to save himself; or may be produced by the body being thrown backwards during wrestling. And, again, direct violence applied to the back of the thigh while the limb is

in a position of abduction may also produce this dislocation.

Symptoms.—Of all the dislocations of the hip, the one upwards and inwards, on to the pubes, is the one most easy of recognition. The most marked sign, and the one which at once establishes the nature of this injury, and its differential diagnosis from fracture of the neck of the thigh bone, with which it is possible it might be mistaken on account of the shortening and eversion that takes place, is the presence of the head of the bone in its new position. It can always be distinctly felt in the groin, rather above the level of Poupart's ligament, feeling like a hard round ball, which moves under the hand when any movements of the limb are made by the surgeon.* There is considerable deformity about the hip. An appearance of general flattening, with an absence of the prominence of the trochanter, and a hollow in the situation where this process ought to exist. The trochanter can sometimes be defined some distance below and internal to the anterior superior spinous process of the ilium. There is slight shortening of the limb, generally to the extent of three-quarters of an inch to an inch in amount. The knee and foot are very considerably everted, and more or less abducted from the middle line of the body (Fig. 85). A certain amount of outward rotation is permitted, but inward rotation is impossible. Some slight amount of flexion can also be produced, but causes great pain. The knee cannot be approximated to the one on the opposite side. The patient often complains of great pain in the groin, extending down the front and inner

* In two cases recorded by Mr. Stokes, one under his own care, the other under Professor Bennett's, the head of the bone was not to be felt. But in these cases the femur had been dislocated above and partially behind the pubes, and in consequence of the head of the bone sinking into the pelvis, it could not be felt by external manipulation (*British Medical Journal*, Dec. 11, 1880).

side of the thigh, and even down the inner side of the leg. This is due to stretching and injury of the anterior crural nerve.

Fig. 85.—Dislocation of the Head of the Femur on to the Pubes.
The illustration represents the deformity which is produced in dislocation of the head of the femur on to the pubes. (After Astley Cooper.)

Treatment. — Reduction of the pubic dislocation may generally be effected, after the patient has been thoroughly anæsthetised, by manipulation.

Several different modes of procedure have been advocated by different surgeons for effecting reduction by this means. Probably the best, because it is based upon the sound principle of making the head of the bone retrace the path by which it has arrived at its new position, is to lay the patient flat on his back on the floor, and to flex his leg on the thigh and the thigh on the pelvis in an abducted position, so that the knee is carried beyond the line of the side of the body. After this motion has been accomplished, the thigh is circumducted inwards, so that the knee is carried to a line parallel with the median line of the body. By this means the head of the femur is forced round the cotyloid cavity to its lower and inner side;

in other words, to the position in which it was primarily displaced, and opposite the rent in the capsule. Care must be taken not to carry the knee, during the circumduction inwards, beyond the median line of the body, otherwise it will slip past the socket and a displacement backwards be the result. The head being now at the lower and inner part of the acetabulum, the surgeon rotates the thigh outwards, and at the same moment extends the limb, so as to bring the knee down to the ground. This will turn the head of the bone backwards and upwards through the rent in the capsule and raise it over the brim of the cavity, and it will be felt to recede into its natural position.

Professor Pirrie and others recommend inward rotation. They flex the thigh on the pelvis, adduct, rotate *in*wards, and bring down the knee. And the manœuvre appears to succeed in some cases equally as well as the rotation outwards.

This dislocation may also be treated by extension, combined with manipulation. The thigh is to be drawn downwards by the surgeon, seated facing his patient with the heel in the perinæum, so as to make counter-extension, and then to be rotated inwards and outwards, and moved from side to side until the head is felt to recede into its natural position. Mr. Erichsen recommends that the thigh should be drawn downwards, and then flexed gradually on the abdomen and rotated inwards. The plan advocated by Mr. Kelly (*see* page 448) is also equally applicable for this, as for the obturator dislocation.

If, from any cause, reduction by the means enumerated above cannot be effected, recourse must be had to extension by means of the pulleys. The plan advocated by Sir Astley Cooper must be adopted. The patient is to be laid at the edge of the couch, and the pelvis fixed by a girth, carried between the perinæum

and the dislocated limb and fixed in the wall a little above and behind the line of the body. The pulleys are fixed to the lower part of the thigh, just above the knee, by a leather collar, and extension is made downwards, backwards, and outwards by fixing the other end of the pulley to a staple driven in the floor to some distance beyond and external to the foot of the bed (Fig. 86). After extension has been made for some time, an

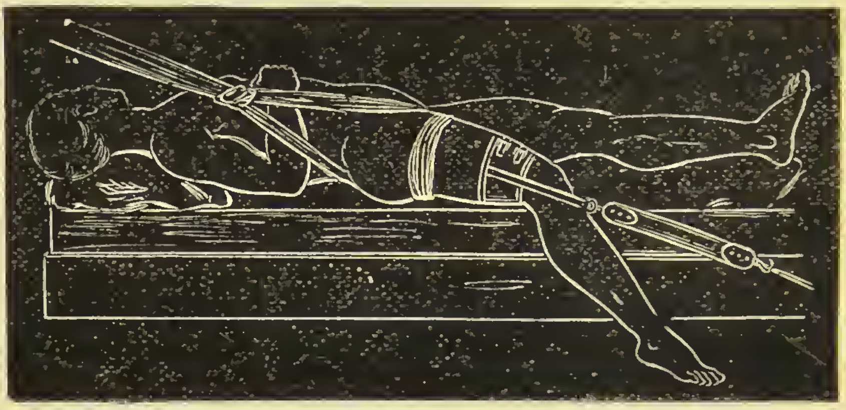


Fig. 86.—Reduction of Dislocations of the Hip on to the Pubes by pulleys.

The illustration shows the method recommended by Sir Astley Cooper of reducing dislocations of the femur on to the pubes by the application of pulleys. (After Astley Cooper.)

assistant lifts the head of the bone over the brim of the acetabulum, by means of a towel passed around the upper part of the thigh. Sometimes rotation inwards during extension will facilitate reduction.

Anomalous or irregular dislocation of the hip.—A very considerable number of anomalous or irregular dislocations of the hip have at various times been recorded, and are to be found scattered up and down the pages of medical literature. It would be impossible, even if it were profitable, in the narrow limits of this work to enumerate all these cases. Still, at the same time, it is impossible to entirely ignore these irregular forms of displacement, and it seems

advisable to advert briefly to some which appear to be of importance, and to have constant and distinctive characters. At the same time, bearing in mind that those mentioned are not the only anomalous dislocations which may occur, but that many varieties of each form may take place, and that, as was pointed out at the commencement of this chapter, there is good reason to believe, as Mr. Bryant has so aptly expressed it, "that the head of the thigh bone may rest at any point round its socket."

In the dislocations backwards, the principal anomalous or irregular dislocations are (1) when the head of the femur is much in advance of its usual position on the dorsum ilii and rests on the bone above the anterior inferior spinous process, or even in front of this process, so that the neck of the bone rests against the notch between the superior and inferior spinous processes. This form has received the name of the "*supraspinous.*" (2) When the head of the bone, being displaced downwards and backwards, rests upon the upper part of the tuberosity of the ischium, or somewhat near the small sciatic notch, or it may be in this cavity. (3) When the head of the bone lies near the anterior superior spinous process of the ilium, and the limb is *everted.* This is sometimes called "*Monteggia's dislocation.*" Of the anomalous dislocations forwards, (4) the dislocation into the perinæum; (5) the subspinous, and (6) that where the head of the bone is thrown above and partially behind the pubes (the "*suprapubic*") are the most important.

1. **Supraspinous.**—This appears to be a by no means uncommon modification of the dislocation on to the dorsum ilii. There is very considerable shortening, sometimes as much as three inches. The hip is flattened and the whole limb everted. The trochanter cannot be felt. The head of the bone is, however,

plainly to be felt above and internal to the anterior inferior spine, moving in unison with the movements of the thigh. Any motion of the limb can only be accomplished with difficulty, and is attended with great pain.

2. In the dislocation **downwards and backwards** there is shortening, and the limb is strongly inverted, so that, as in a case recorded by Sir Astley Cooper, "the limb formed half a right angle with the body." The thigh in these cases is sometimes markedly flexed; at other times, less so. When the displaced head rests on the tuberosity of the ischium it is plainly to be felt, when it is lodged in or near the lesser sciatic notch it is not so distinct.

3. **Monteggia's dislocation.**—Perhaps the most important of these anomalous dislocations is the one known by the above name, inasmuch as the eversion which exists in these cases might constitute a probable source of error in diagnosis. The dislocation to a very considerable extent resembles the *supra-spinous*, where also there is eversion; but the head of the bone usually lies on the dorsum, though considerably nearer the anterior superior spinous process than in the ordinary form of luxation. The principal characteristic is that the limb is rotated considerably outwards, instead of inwards, otherwise it resembles in its symptoms the ordinary dorsal form of dislocation.

4. **Dislocation into the perinæum** has already been alluded to. It must be simply regarded as an exaggerated form of the luxation into the obturator foramen. The symptoms are the same, but more pronounced.

5. **Subspinous.**—This dislocation has also been mentioned in the section devoted to the consideration of dislocation on to the pubes. The head of the bone is placed a little below and to the inner side of the anterior inferior spinous process of the ilium, resting against

the front of the horizontal ramus of the pubes. There is shortening, and rotation outwards as in the dislocation on to the pubes, but the limb is less abducted and less advanced than it is in this form of luxation.

6. **Suprapubic dislocation.**—Stokes has described two cases of dislocation forwards and upwards, where the head of the bone was displaced above and partially behind the pubes, and proposes to designate them by the term "*suprapubic dislocation.*" The symptoms observed appear to be identically the same as those met with in ordinary dislocation on to the pubes, with the exception that the head of the bone cannot be felt.

Old dislocations.—In dislocations of the hip which have been allowed to remain unreduced, the question will sometimes arise as to how long after the accident the reduction should be attempted. Two points have to be considered in connection with this subject; first, the possibility of reduction; and secondly, the advantages to be gained if the reduction is effected, and the disadvantages which may arise from the efforts of the surgeon to replace the head of the bone. With regard to the first point, namely, the possibility of returning the head of the bone into its socket, there can be no doubt that the attempt is far more hopeful in the present day, with the advantage derived from anæsthetics, than it was in Sir Astley Cooper's time, who fixed a period of two months as that during which reduction should be effected. Under the influence of ether or chloroform adhesions can be broken down by properly applied force, and the resistance of muscles, even when shortened and rigid from inflammatory changes, overcome in a manner which could not be accomplished in Sir Astley Cooper's time. So that cases have been recorded where dislocations have been reduced at a very much longer period than that above

named; and the first question, in the present day, must be answered in the affirmative, namely, that it is possible to reduce the dislocation even after the lapse of five, six, or perhaps even twelve months.* Whether, however, the advantages to be gained from the proceeding compensate the patient for the risks which he must run and the probable harm which may result, is a very doubtful point. After the lapse of three or four months such considerable changes occur in the old socket and the head of the bone, that it is very questionable whether the patient would not have a more serviceable limb by allowing the bone to remain in its new position and endeavouring to establish a false joint than by effecting reduction, even supposing this could be done without any injury to surrounding structures.

Treatment after reduction.—After the reduction of a dislocation of the hip, all the treatment which is necessary, in the majority of cases, is to keep the patient flat on his back in bed with the legs tied together for about two weeks. As a rule no splint is required, but it is a good plan and often affords considerable comfort and support to the patient to place a sand-bag on either side of the limb; a short one reaching from the foot to the knee on the inner side, and a longer one, reaching as high as the hip, on the outer side. Under these circumstances it unnecessary to tie the legs together, but it is as well to pass a couple of turns of bandage around the sand-bags, enclosing the leg just above the ankle. By this means the limb is steadied, and any tendency to rotation is prevented. At about the end of two weeks passive motion must be commenced. This must be done with great gentleness and with every possible care; the joint being moved in every direction daily by the surgeon, and between his visits the

* Malgaigne, tome ii., p. 821.

movements of the limb being still restrained by the sand-bags. The great fear in cases of reduced dislocation of the hip is that the displacement may be reproduced by some incautious movement on the part of the patient, and therefore it is well to dissuade him from making any voluntary movements until the torn ligament and muscles shall be reunited, but at the same time passive motion must be employed by the surgeon to prevent partial or complete stiffening of the joint.

In some cases it is found that the dislocation will recur. The patient has been sent back to his bed in the belief that the luxation has been reduced and that the head of the bone has been returned into its normal position, and at the next examination it has been found that the displacement has returned. This will probably be due to the dislocation being complicated with fracture of some part of the rim of the acetabulum, when crepitus will be detected; or in young subjects it may be due to separation of the head of the femur from its neck at the epiphysial line, when there will be no crepitus. It may also be due to the head of the femur having only been partially reduced, and having become lodged in the rent in the capsule, without having passed completely through it; under these circumstances the dislocation will probably be speedily reproduced from muscular contraction or from some incautious movement on the part of the patient. Should such an event occur, an endeavour must be made to again replace the bone, and this will generally be accomplished without difficulty, and then extension must be kept up by means of a long splint or by a weight, the limb being supported by sand-bags. This extension must be maintained for at least four weeks in any case where fracture is suspected, and the patient must be prepared for the result that there will probably be some permanent rigidity about the joint.

Compound dislocations.—A dislocation of the hip joint with an external wound communicating with the joint surfaces is of very uncommon occurrence. This is partially due to the depth of the articulation and the thick layer of gluteal muscles by which it is covered on that side on which dislocation usually occurs, and partly to the manner in which luxations of the hip joint occur. When a compound dislocation of this articulation is produced it is generally caused by some extreme form of crushing violence, and the accident is generally attended by other injuries which speedily render it fatal. Should such a case occur, the displacement must be reduced as in a simple dislocation, and the case treated on ordinary surgical principles. Under any circumstances it must be regarded as an accident of the gravest nature, and fraught with danger from the first.

Dislocation of the Patella.

Dislocations of the patella are usually described as taking place in a direction outwards, inwards, edgeways, or upwards. But the latter form of displacement can scarcely deserve the name of dislocation, though it is a displacement of the articular surfaces from one another. It is, in fact, primarily a rupture of the ligamentum patellæ, or a separation of this ligament from its attachment to the tibia, an accident which sometimes takes place from the same causes as transverse fracture of the patella. The bone is subsequently drawn upwards above its usual situation by the action of the quadriceps extensor, so that this displacement can scarcely with more justice be considered a dislocation than the displacement of the upper fragment of the patella in transverse fracture of this bone. Very much on the same lines a dislocation *downwards* has been described by some authors, a displacement which can only take place when the

extensor muscles of the thigh have primarily been torn from the bone, or ruptured.

Dislocation of the patella outwards.—This is by far the most common form of displacement of the patella. The greater frequency of this variety of displacement is due to two causes, as to whether the injury arises from muscular contraction, or from direct violence.

(1) *If the dislocation arises from muscular action.* When the quadriceps extensor muscle contracts, the tendon of this muscle, the patella, and the ligamentum patellæ, act in a straight line. In consequence of the obliquity of the femur, which forms an angle with the bones of the leg, these structures do not follow the line of the bones, but have a tendency to draw the patella outwards, beyond the angle of the bones. Under ordinary circumstances, in quiet contraction of the muscle, the greater prominence of the external condyle in front counteracts this tendency; but if a sudden and violent contraction takes place, the bone may overcome this obstacle and a dislocation outwards result.

(2) *If the dislocation arises from direct violence.* If a violent blow be received on the patella, the bone mainly resting against the articular surface of the outer condyle is more easily driven in a direction outwards than it would be inwards, in consequence of its not being in such complete contact with the internal condyle, and not, therefore, so liable to glide over it. In addition to this, the inner border of the patella is more prominent and exposed to blows, which have a tendency to force the bone outwards, than the outer border of the bone which is protected by the prominence of the external condyle.

Causes.—Dislocation of the patella outwards may be produced by sudden muscular contraction, or by direct violence. When arising from the first cause, it is said to be more common in people suffering from

genu valgum; but this has been denied by Malgaigne, who states that out of forty-six cases of dislocation of the patella, only one patient had knock-knees. It does, however, undoubtedly occur in this affection, and it seems reasonable to suppose that in those persons where the angle of the bones of the leg with the femur is increased, for the reasons detailed above, dislocation outwards would be more common than in those where the bones were more nearly in a straight line. For the same reason it is said to be more common in females, whose femora have a more oblique inward direction than in males.

Professor Streubel considers the subject of the mechanism of dislocation of the patella, and from experiments on the dead body concludes that it can only occur in joints whose ligaments have been previously relaxed.*

Dislocation of the patella generally takes place when the leg is extended. During the flexed position the patella is sunken between the condyles of the femur, and is firmly held in contact with their articular surfaces by the ligamentum patellæ and the extensor muscles of the thigh. But when extended, or partially extended, these structures and the capsular ligament are relaxed, and the patella is not so fixed, and therefore more likely to be displaced either by a sharp blow or by spasmodic contraction of the quadriceps extensor muscle.

The dislocation may be complete or partial. When *complete*, the bone is thrown entirely off the articular surface of the femur, and undergoes a partial rotation on a longitudinal axis through its own centre. The articular surface of the patella thus rests against the

* Schmidt's "Jahrb.," vol. cxxxix., p. 311, and vol. cxxx., p. 54, 1866. *See* also a case by Mr. John Wood, in which dislocation outwards took place after the joint had been distended by rheumatic synovitis; *Med. Times and Gazette*, vol. ii., p. 638; 1861.

outer surface of the outer condyle; the inner border is directed forwards, and the outer backwards. The ligamentum patellæ is somewhat twisted. In the *partial* dislocation there is not complete displacement of the cartilaginous surfaces from each other. The inner articular facet of the patella rests on the surface of the external condyle. There is also a certain amount of rotation of the bone, so that the outer border is directed forwards, and the anterior subcutaneous surface looks inwards and forwards.

In the complete form of dislocation the anterior part of the capsular ligament is usually torn, and sometimes extensively so; but this is not necessarily the case, for it would appear that complete dislocation may occur without laceration.* Incomplete luxation can undoubtedly occur without any laceration of the capsule at all.

Symptoms. — The leg is extended or slightly flexed, and is fixed in this position, any attempt to flex the limb being attended with very great pain. The knee is flattened and appears broader than natural, and a depression is to be felt in the position which the patella normally occupies, and at the bottom of this the groove between the condyles of the femur can sometimes be made out. On the outer side of the joint is to be felt a hard mass, which can usually, without difficulty, be recognised as the patella, especially if the limb is semiflexed. The tendon of the quadriceps extensor forms a hard tense band above the patella, having an oblique direction, upwards and inwards, and if the limb is extended the ligamentum patellæ stands out in relief, less so if the limb is flexed. In the *partial* displacement the limb is extended, and the patella forms a prominent swelling on the outer border of the articular surface of the femur. The

* Mr. Morris records a case from the Musée Dupuytren, in which he believes this is the case; "System of Surgery," vol. i.

external border can be felt prominently projecting forwards under the skin, and the flat anterior surface, inclined inwards, can be traced downwards into a depression between the condyles. The external articular facet of the patella can be felt beneath the skin behind the prominent external border.

Dislocation inwards.—This form of dislocation is of very rare occurrence. From recorded cases it would appear to be always caused by direct violence applied to the outer edge of the bone, and never to be the result, like the displacement outwards, of muscular contraction. This form of dislocation may be either complete or incomplete. In the former case the patella is completely thrown off the articular surface of the femur, and undergoes the same partial rotation as occurred in the other form of dislocation. The cartilaginous surface of the patella rests against the inner surface of the inner condyle, and the outer margin of the bone projects forwards, so that the ligamentum patellæ is partially twisted. In the incomplete dislocation the outer articular facet of the patella rests against the inner condyle of the femur, and the inner border is directed forwards, the outer being buried in the intercondyloid notch.

The symptoms are very much the same as in those of the dislocation outwards, with the exception, of course, of the fact that the patella forms a prominent swelling on the inner instead of the outer side of the joint. The limb is extended, or only slightly flexed, and fixed in this position, any attempt to move it causing great pain. There is a depression in the normal position of the patella, at the bottom of which the intercondyloid notch of the femur can be felt, provided the amount of swelling is not great. The patella forms a well-defined tumour on the inner side of the internal condyle, its external border being prominently marked and projecting forwards under

the skin in the complete dislocation; whereas, in the incomplete form, the symptoms are less marked and the internal border tilts forwards.

Treatment.—The reduction of these dislocations outwards or inwards is generally effected without difficulty. It is for the most part desirable to administer an anæsthetic to facilitate reduction, but if this should not be available, the end can generally be accomplished without it.

The first object is to relax as far as possible the quadriceps extensor muscle, and this is to be done by laying the patient on his back, with the trunk raised by means of pillows, and flexing the thigh on the pelvis. The knee is then to be grasped by the fingers of the surgeon, and the margin of the patella which is farthest from the centre of the joint forcibly depressed. This will have the effect of raising the other edge, which, being tilted over the condyles, is immediately drawn by the action of the muscles into its natural situation. The best manner of accomplishing this is for the surgeon to kneel on the bed, facing his patient. He then places the injured limb on his shoulder, and by carrying his body forwards over that of his patient, acutely flexes the thigh on the pelvis (the leg at the same time being extended on the thigh), and has at the same time both hands free to manipulate the displaced bone into position.

After reduction, some swelling and effusion into the joint must be anticipated, and the limb should be fixed on a ham-splint, and ice or Leiter's tubes applied for a few days. At the end of two or three weeks passive motion should be commenced, but the limb during the intervals of movement should be kept quiet with a knee-cap for some weeks longer. And, inasmuch as these dislocations are very liable to recur on the slightest cause, it is often advisable to recommend a patient, especially if there is any tendency to genu

valgum, to wear some artificial support, in the shape of an elastic knee-cap or bandage, for the rest of his life.

Dislocation edgeways (or vertical rotation) of the patella.*—In this peculiar displacement the patella undergoes a vertical rotation around a longitudinal axis through the centre of the bone. In consequence of this, its surfaces, instead of being directed forwards and backwards, are directed inwards and outwards, while one of its borders projects prominently under the skin, and the other is lodged in the intercondyloid notch. It would appear that in the majority of cases the rotation of the bone is in a direction outwards, so that the outer border is wedged into the notch, while the inner border projects forwards under the stretched skin. In some cases a greater rotation even than this takes place, and the bone may be turned almost completely round, so that the anterior subcutaneous surface faces the condyles, while the posterior articular surface presents anteriorly.

Causes.—The principal cause of this singular accident appears to be a direct blow on the edge of the patella, while the limb is in a semiflexed position. In other cases the accident has been said to occur from violent muscular contraction, conjoined with a twist of the leg, as in jumping with the foot inverted or everted.

Symptoms.—The symptoms of the dislocation are most marked, and can scarcely be mistaken. The patient complains of severe pain in the knee, especially upon any attempt being made to move it. The limb is completely extended, and any attempt to flex it impossible without causing the most violent pain.

* A series of cases, twelve in all, of vertical rotation of the patella are recorded in the *Medical Times and Gazette* for 1862. *See* vol. i., pages 189, 230, and 264; and vol. ii., page 263. Also a case, vol. ii., page 550; 1857.

The patella is easily to be felt, its prominent border forming a hard well-marked ridge under the stretched skin, with a depression on either side of it.

Treatment.—In the majority of cases reduction can be effected without much difficulty, but occasionally cases have been recorded in which the greatest amount of difficulty has been experienced in effecting reduction, and in some rare instances it has been found to be impossible, even though the ligamentum patellæ and the tendon of the quadriceps extensor muscle have been freely severed from the bone. Probably the difficulty in these cases has arisen from the bone being locked in a hole in the capsule, or from having become entangled or twisted in the aponeurotic structures which surround and cover it. According to Malgaigne, the difficulty arises from the upper extremity of the bone becoming firmly wedged in the intercondyloid notch.

As a rule, reduction of the displacement may be accomplished by suddenly and forcibly bending the knee. Again, in other cases reduction may be effected by manipulation, while the limb is in an extended position. The leg being extended on the thigh, and the thigh flexed on the pelvis, as in the reduction of the lateral displacements of the patella, the prominent edge of the bone is to be firmly pressed upon in such a direction as to cause it to undergo a retrograde vertical rotation to that which it has taken in producing the displacement. Cases must be very rare indeed in which these methods, efficiently applied, under the influence of anæsthetics, will not succeed in effecting reduction, so as to necessitate what has been recommended by some surgeons, the subcutaneous division of the ligamentum patellæ or any part of the capsule which may be felt to be on the stretch. Such a proceeding is not to be rashly undertaken, nor, indeed, do the records of cases where it has been done

induce us to resort to such a measure, since even after division of these structures failure to effect reduction has occurred, and the operation has been attended with the most serious and even fatal results. At the same time, it must be borne in mind, before these considerable risks are encountered, that failure to effect reduction does not condemn the patient to any very serious evil, since a fairly useful limb will probably result, even though the dislocation is allowed to remain unreduced.

Dislocation of the Knee.

Traumatic dislocation of the knee is, by no means, a common accident, and is always the result of extreme violence. Dislocation may, however, occur in four principal directions, viz. forwards, backwards, inwards, and outwards; or in some cases we may have a combination of two of these displacements, and the tibia may be dislocated from the femur either forwards and laterally or backwards and laterally.

All these dislocations may be complete or incomplete. The rule would appear to be for the lateral dislocations to be partial, and the antero-posterior complete. To this rule, however, there are many exceptions.

The lateral dislocations are of more common occurrence than the antero-posterior; so that the usual dislocation is a partial dislocation laterally, the external articular surface of the tibia being thrown on to the internal condyle of the femur, or the internal articular surface of the tibia on the external condyle of the femur.

Causes.—These dislocations can only be produced by very extreme violence, sufficient to tear the strong ligaments which bind the bones together. The form of violence by which the injury is usually produced is when some force is applied to the femur while the leg is fixed, especially if it is associated with some

rotation or twisting of one bone on the other. It therefore often arises from a person jumping from a carriage whilst it is in rapid motion, or by falls from a great height. As soon as the feet reach the ground they become a fixed point, and the weight or momentum of the body, especially if it is combined with some twisting of the trunk, causes an enormous strain on the ligaments of the knee joint, which give way, and dislocation is produced. The accident may also be caused by a person falling from his horse while it is running away, and being carried along with it from the foot becoming entangled in the stirrup. Less commonly the accident may be occasioned by violence applied to the leg while the thigh is fixed.

Dislocation forwards.—Displacement of the tibia forwards from the femur is a more common accident than displacement of the same bone backwards, and may be complete or incomplete, generally the former. The displacement in these cases is very great, the popliteal surface at the back of the tibia resting on the anterior surface of the lower end of the femur, so that the articular surface of the former bone is sometimes as much as four inches (Astley Cooper) above the level of the extremity of the condyles of the latter (Fig. 87). Often, also, there is a slight lateral displacement as well, so that the inner tuberosity of the tibia projects on the inner side, or the head of the fibula on the outer side. In the dislocation forwards the projection of the condyles of the femur in the popliteal space appears to produce more compression than the head of the tibia does in the backward dislocation, and sometimes even severely injures and lacerates the popliteal vessels and nerve.

Symptoms.—The deformity which is produced by this dislocation is so marked that the nature of the lesion can scarcely escape recognition. The limb is generally extended, but may be flexed, and there is

usually a certain amount of rotation of the leg, sometimes inwards, sometimes outwards, according as the tibia is displaced inwards or outwards from the middle line of the limb. There is considerable shortening, sometimes to the extent of four or five inches (R. Adams), generally about two or three inches. The condyles of the femur are plainly to be felt and recognised by their rounded form, under cover of the muscles of the calf. Below them is a hollow or depression. The head of the tibia projects in front, forming a marked swelling in front of the knee on a higher level than the swelling produced by the condyles of the femur behind. The patella is generally situated in a hollow above the articular surface of the tibia, and is quite movable, the quadriceps extensor being lax and loose. Sometimes, however, it is stated that the patella has been found resting in front of the tuberosities of the tibia, or displaced to one or other side of them. The limb below the knee is swollen and cold, and the pulsation in the tibial arteries is absent, or much more feeble than on the opposite side of the body. Occasionally intense pain is complained of in the leg and foot from compression of the internal popliteal nerve.

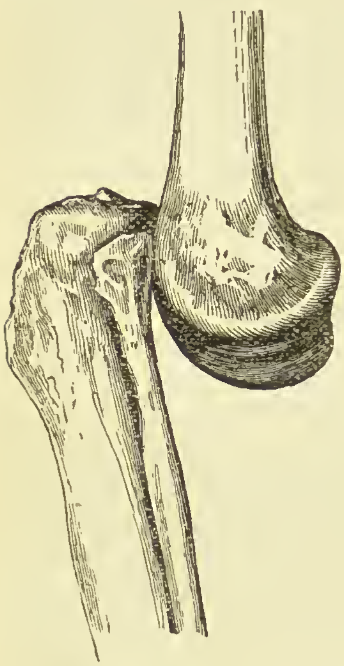


Fig. 87.—Dislocation of the Knee forwards.

The popliteal surface of the tibia rests on the anterior surface of the lower end of the femur, so that the articular surface of the bone is some inches above the level of the extremities of the condyles of the femur.

Dislocation of the tibia backwards.—This form of luxation appears to take place less frequently than the dislocation forwards as the result of injury, though a much more frequent condition when arising from pathological causes, in consequence of the action of the hamstring muscles having a tendency to gradually displace the tibia backwards after destruction of the articulation has taken place. The dislocation may be complete or incomplete. When it is complete the displacement of the bones does not appear to be as great, in the majority of cases, as in the forward luxation. The anterior surface of the upper margin of the tibia, as a rule, rests against the posterior surfaces of the two condyles of the femur at their most prominent part. Sir Astley Cooper has, however, recorded a case in which the head of the tibia was displaced backwards and upwards above the level of the condyles, and rested against the popliteal surface at the back of the femur.

Symptoms.—The signs of the dislocation are well marked, and the alteration in the shape of the limb is so characteristic that the injury can hardly be mistaken. The limb is generally semiflexed, but may be extended. In some cases it has been stated that it has been found to be hyper-extended and bent forwards. There is a well-marked rounded projection of the condyles of the femur, with the skin tensed over them at the front of the knee, and a transverse depression below; or if the limb is flexed, the ligamentum patellæ stands out in relief with a marked depression on either side of it (Fig. 88). The patella rests on the groove between the two condyles in an oblique direction, so that its anterior surface is directed more or less downwards, and its upper border projects forwards. The head of the tibia is to be plainly felt in the ham, where it forms a projection among the muscles of the calf. There is shortening of the limb,

but rarely to the same amount as in the other antero-posterior dislocation. It seldom exceeds an inch and a half, or at the most two inches.

In the incomplete forms of these antero-posterior dislocations the symptoms are the same as in the complete form, differing only in their degree, being less pronounced, less marked. In the incomplete form, whether forwards or backwards, the popliteal vessels and nerve usually escape any serious amount of compression.

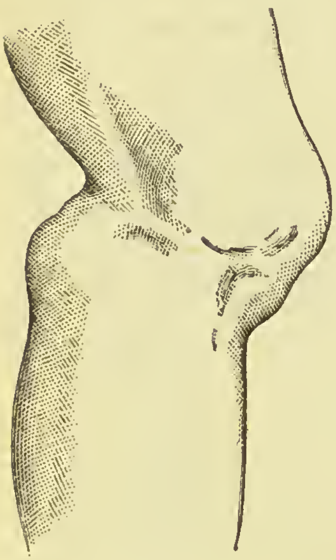


Fig. 88.—Dislocation of the Tibia backwards.

The figure represents the deformity which is produced by dislocation of the tibia backwards from the condyles of the femur.

Treatment. — The reduction of these dislocations is generally easy, the amount of laceration of surrounding structures is so great that no impediment is offered by their tension in effecting reduction, and at the same time the anatomical configuration of the bones entering into the formation of the joint offers little or no obstacle to its easy accomplishment.

It is generally advisable to place the patient under the influence of an anæsthetic, though if this is not easily to be obtained, and the dislocation is recent, it is probable that the reduction may be effected without this means. The patient being laid on his back, and counter-extension being made by an assistant grasping the upper part of the thigh with both hands, or, what is better, by means of a belt passed between the thighs and fastened to the head of the bed, so that it shall press upon the ramus of the pubes and

ischium, a second assistant makes extension from the ankle and foot in the direction of the axis of the misplaced leg. After steady extension has been maintained for some time, the surgeon should endeavour to facilitate reduction by making firm pressure on the projecting head of the tibia; in the dislocation forwards, the head of the bone being pressed downwards and backwards; in the dislocation backwards, being pressed in the opposite direction; while, at the same time, he steadies the lower end of the femur with the other hand. Some surgeons recommend that extension should be made while the thigh is in a flexed or semiflexed position, in order that the quadriceps extensor muscle should be more or less relaxed, but this would appear to be scarcely necessary, the muscle being flaccid and offering no impediment to reduction.

After the bones have been replaced in position, the limb is to be maintained in a condition of perfect rest on a splint for two or three weeks, and cold lotions or ice applied in order to combat the secondary inflammation and effusion which is sure to follow. At the end of this time passive motion should be commenced, at first carefully and cautiously, and the limb in the interim maintained in a fixed position. For some time the patient should be enjoined to wear a knee-cap, since the main support of the joint, the ligaments, having been more or less extensively ruptured, a recurrence of the dislocation is likely to result unless some artificial means of support is employed.

If the circulation in the tibial arteries has been partially or completely arrested by the pressure of the displaced bone, it will in all probability speedily return upon the reduction of the dislocation. Should it not do so, and should the limb remain swollen, the case will assume a very serious aspect, as this will be

evidence that the popliteal vein or artery has been injured, and that amputation will be necessary. The advent of gangrene will at once determine the point.

Lateral dislocations of the knee.—The displacement of the tibia to one or other side of the femur appears to be a more common accident than the antero-posterior displacement. But, unlike it, it is generally partial or incomplete. Complete lateral dislocation may, however, take place without laceration of the skin. Mr. Hulke states that two cases of complete simple lateral dislocation are recorded by Pitha.*

These dislocations may be either inwards or outwards; that is to say, the outer tuberosity of the tibia may be displaced on to the inner condyle of the femur, or, *vice versâ*, the inner tuberosity of the tibia may be displaced on to the outer condyle of the femur.

The **causes** of this accident are much the same as those which produced the antero-posterior dislocations, except that the force is applied in a different direction; a blow or any violence applied laterally to the leg while the thigh is fixed, or to the thigh while the leg is fixed, will produce this dislocation. There is in the Musée Dupuytren a specimen of lateral dislocation of the knee, in which the luxation was produced by a violent twist outwards of the leg of a patient who was tied up in the lithotomy position.

Symptoms.—The signs of lateral dislocation are so marked and characteristic that a mistake in diagnosis is not likely to occur. In the displacement of the tibia **outwards** the internal condyle of the femur projects prominently under the skin on the inner side of the joint, with a depression below, while the head of the fibula and the outer tuberosity of the tibia protrude on the outer side of the knee, with a

* *Medical Times and Gazette*, vol. ii., p. 461; 1876.

cup-shaped cavity above. The limb is partially flexed and the toes generally everted, but there is no shortening. Sir Astley Cooper states that the condyles are thrown somewhat backwards as well as laterally, and that there is therefore a greater prominence than natural of the tibia in front.

In the dislocation **inwards**, the symptoms, *mutatis mutandis*, are the same as in the dislocation outwards. There is a prominence of the outer condyle on the outer side, and of the inner tuberosity of the tibia on the inner side, producing great deformity of the knee, which is easily recognised.

There is one form of injury which may be mistaken for these dislocations, viz. separation of the epiphysis of the lower end of the femur, and displacement of this fragment of bone with the bones of the leg; and in every case in which dislocation of the knee has been supposed to have taken place, in the young subject, the surgeon should be alive to the possibility of such an accident having occurred. The ease with which the deformity can be reduced by slight extension, and the tendency which it has to recur when the extension is withdrawn, with the possible presence of crepitus or pseudo-crepitus, will at once point to the nature of the injury.

Treatment.—The treatment in these cases is simple, and the reduction of the dislocation as a rule effected without difficulty. The patient having been anæsthetised and the thigh having been fixed as in the antero-posterior dislocations, the surgeon is to make firm and steady extension from the ankle, at the same time gently moving the leg from side to side, and if necessary combining this movement with slight rotation. Under these circumstances the bones will generally, without much difficulty, be restored to their natural position. The limb must then be confined on a splint, and any consecutive inflammation

be treated on ordinary surgical principles. In some cases the injury will be followed by comparatively little disturbance, and the patient recover speedily with a perfectly useful limb. But, on the other hand, violent inflammation may follow, and in spite of the best endeavours of the surgeon, a permanently disabled and partially stiffened limb may result ; or in other cases suppuration may ensue with complete destruction of the articulation, necessitating amputation. Lastly, from the injury sustained by the ligaments the joint may remain weak and insecure for a considerable period of time.

Dislocation of the semilunar fibro-cartilages.—Mr. Hey first drew attention to these injuries, and called them cases of "internal derangement of the knee joint," but he does not appear to have arrived at any very definite idea as to the nature of the injury. He says, "The knee joint is not unfrequently affected with an internal derangement of its component parts, and this sometimes in consequence of trifling accidents."

From symptoms which will be presently detailed, it will be seen that this accident closely resembles a "loose cartilage" in the joint, and there can be little reason to doubt that many of the cases which have been described as instances of dislocation of the semilunar cartilages have in reality been loose bodies in the joint.*

In other cases which have been recorded the exact nature of the injury is doubtful, and since Sir Astley Cooper's time a considerable difference of opinion has existed among surgeons as to whether an actual displacement of one of the semilunar cartilages

* It must be borne in mind, also, that a portion of one of the semilunar cartilages may become chipped off, and form a loose body. *See* a case by Mr. Brodhurst; Path. Soc. Trans., vol. xvii., 1874.

can in reality occur. Professor Humphrey says he can "scarcely understand how it should take place, their convex edges being connected with the synovial membrane all round." * The accident is now however, regarded as a recognised one in surgery, and at least two cases have been recorded where the displacement has been proved by dissection.†

The displacement appears to take place in two directions; that is to say, the cartilage may either be displaced inwards towards the spine of the tibia, or outward, so that it projects beyond the margin of the tibia.

A good example of the *inward* displacement is recorded by Mr. Rickman Godlee, taken from an old knee joint in the anatomical museum of University College, to which there was no history attached. "The circumference of the fibro-cartilage had been torn away from its attachment to the capsule of the joint, and it now occupies a vertical position in the intercondyloid notch." It is said that sometimes in these cases where displacement inwards has taken place, the cartilage may be dislocated partially backwards as well, so as to occupy a position posterior to its normal condition. In the displacement of the cartilage outwards it projects beyond the margin of the articular surface of the tibia and the condyles of the femur, and it would therefore appear to be necessary in these cases that the cartilage should be torn from its attachment to the bone, from the depression in front and behind the spine of the tibia, into which it is firmly implanted. It would seem, therefore, to be probable that a much greater degree of violence would be required to produce the displacement outwards than inwards. As far as I am

* Humphrey, "On the Skeleton," p. 547.

† Ferguson; "Practical Surgery," p. 323. 5th ed. Godlee Path. Soc. Trans., vol. xxxi., p. 240.

aware, no dissection has ever been made in which the outward dislocation has taken place.

It is generally stated that displacement of the inner cartilage is of more common occurrence than the outer. This statement appears to have been derived from an article in "Cooper's Surgical Dictionary," where it is stated that the projection of the cartilage, was almost invariably on the inner side of the knee, and that only in one case was it at the outer side ; or, in other words, that in the *outward* displacement, at all events, it was the internal cartilage which was dislocated in every instance but one. Mr. Godlee has, however, adduced some very cogent anatomical reasons for supposing that it is most likely that the external and not the internal fibro-cartilage would be the one to slip.* The outer cartilage has much less extensive attachment to the capsular ligament than the inner one. It is more movable. It has only a slight attachment to the posterior ligament and to the internal crucial ligament, whereas the internal fibro-cartilage is intimately adherent to the posterior and also to the internal lateral ligament.

Causes.—The causes which may give rise to displacement of one of the semilunar fibro-cartilages are often very slight; a sudden twist of the leg or foot while the knee is in a flexed position will occasion the accident.

Sir Astley Cooper states that the accident most frequently occurs when a person in walking strikes his toe, with the foot everted, against any projection, such as a fold of carpet. But that he has seen it happen from a person having suddenly turned in his bed, when the clothes not suffering the foot to turn readily with the body, the cartilage has slipped from its position. It would seem probable that a condition of flexion, or semiflexion, is always

* *Op. cit.*, p. 241.

present when these cartilages are dislocated; for during extension they are flattened out and squeezed into a larger circle between the condyles of the femur and the articular surface of the tibia, and would therefore be more or less immovably fixed while the bones are in this position. During flexion, on the other hand, in consequence of the bones not being quite so tightly braced together, from the more relaxed condition of the ligaments, the circle of the cartilage contracts again and is more movable on the upper surface of the tibia. Moreover, during extension of the joint no rotation of the leg is possible, and the semilunar cartilages remain fixed on the tibia, whereas during flexion a certain amount of rotation at the knee is possible, and during this movement the fibro-cartilages rotate on the tibia. There is no doubt also, and this is what we should naturally expect, that joints which have been the seat of inflammatory changes, especially when it has been attended by considerable effusion, are more prone to this injury than a healthy articulation on account of the relaxation which the ligaments have undergone.

Symptoms.—The patient, after making some sudden muscular effort, is conscious of having strained or injured his knee. Thus, whilst walking, he may strike his toe against a stone, or some inequality in the ground, and is suddenly seized with a severe and sickening pain in the knee, often of so acute a character as to cause him to fall. Upon examination the limb will be found to be semiflexed and fixed in this position, so that the patient is utterly unable to move the joint in the slightest degree. Passive motion, either in the direction of extension or of flexion, may be possible, though the movements are usually attended by great pain, but any voluntary attempt on the part of the patient to move his joint

is completely futile. The ligamentum patellæ is usually relaxed.

If the semilunar cartilage has been displaced away from the spine of the tibia, it will be at once recognised as a rounded, smooth projection on the inner or outer side of the joint, according as the internal or external fibro-cartilage has been the subject of the accident. But if the cartilage has been displaced inwards and rests in the intercondyloid notch there will be no projection, though there may be a slight prominence on one or other side of the ligamentum patellæ from the antero-posterior elongation of the cartilage in its new position. It is possible that a depression may be felt between the condyle of the femur and the head of the tibia, in the position from which the cartilage has been displaced. The injury is usually followed by synovitis and rapid effusion into the joint, so that the symptoms are speedily masked by the globular swelling due to this effusion, and the injury is very liable to be mistaken for loose cartilage, or even for simple sprain.

Treatment.—The plan of treatment recommended and adopted by Hey is usually successful in restoring the cartilage to its natural position. This consists in flexing the leg on the thigh to its fullest extent; this relaxes the amount of pressure of the condyles of the femur on the displaced cartilage, and then by suddenly extending the leg on the thigh reduction is effected.

The evidence of reduction is very complete, the sensation of the patient that "all is right," the cessation of pain, and the power to move the joint which at once follows reduction, at once proves that this has been satisfactorily accomplished. The accident, however, having once occurred, is very liable to recur, and the patient's knee should be supported for some years by a knee-cap or elastic bandage.

After reduction, the knee should be kept quiet for some days on a splint, and cold lotions or ice applied until all symptoms of inflammation of the synovial membrane have subsided; as soon as this has taken place, passive motion should be commenced, and diligently persevered with, in order to prevent any permanent stiffness of the joint remaining. In some instances it has been found to be impossible to effect reduction, and in others it has been found that, though the cartilage could be returned to its natural position, a recurrence of the displacement almost immediately takes place. Under these circumstances a very useful limb may be obtained by perseverance in passive motion; the cartilage appears to adapt itself to its new position,* and the patient is enabled to get about with very little inconvenience. It is essential, however, in these cases that passive motion should be begun early, and steadily persevered in. Prolonged rest will do no good, and as soon as the symptoms of synovitis have subsided, systematic shampooing and moving of the joint should be commenced, the patient at the same time being encouraged to use his leg freely.

Compound dislocation of the knee joint is a most serious injury; one, indeed, of the most serious injuries to which the limbs are liable, and in the majority of cases necessitates the removal of the part by amputation. The wound is generally large, more or less lacerated and contused, and the soft structures in the neighbourhood are usually so much injured as to require an immediate operation. Even if the nature of the local injuries is not so great as apparently to demand primary amputation, there is the danger of prolonged and exhaustive suppuration, with possibly necrosis to consider, if an attempt is made to save the limb. If the large vessels or nerves in

* This especially applies to the internal displacement.

the ham are in any way injured, there can be no doubt as to the propriety of immediate amputation, since the risk of gangrene is added to the other dangers of the accident. If the patient is young and of sound constitution, the popliteal vessels and nerves uninjured, and the soft parts around not much involved, an attempt may be made to save the limb. The question will then arise as to the propriety of formally excising the joint, or of simply reducing the protruding bone, securing efficient drainage, and endeavouring to obtain anchylosis by rest and appropriate treatment. Cases have been recorded where either plan has been tried, and has proved successful,* and the selection of one or other method of treatment must be left to the discretion of the surgeon in any particular case which may fall under his care, and he will be guided in his decision principally by the fact of the ease with which reduction can be effected, and the amount of contusion and injury which has been done to the protruding articular surface.

Dislocation of the Fibula.

Dislocation of the upper end of the fibula.—Under this term have been classed together a number of cases which can scarcely be regarded as true traumatic dislocations of the upper end of the bone. Occasionally, for instance, in consequence of relaxation of the tibio-fibular ligaments, the articular surface of the fibula becomes displaced from that of the tibia; these cases of dislocation can, however, hardly be classed as traumatic dislocations. Again, in some cases an oblique fracture has taken place through the upper end of the tibia, separating a

* A case is recorded of compound dislocation outwards and backwards, in which recovery took place with "nearly complete movement" (*Medical Times and Gazette*, vol. ii., p. 567; 1872).

fragment, with which the head of the fibula articulates, from the rest of the bone. This fragment, together with the upper end of the fibula, has been displaced by muscular action, and these cases have been classed as dislocations of the head of the fibula. Nevertheless, true traumatic dislocation at the upper tibio-fibular articulation does occasionally take place,* the upper end of the fibula being driven either forwards or backwards in the majority of cases. In one remarkable case the dislocation was *upwards.* The case is recorded by Malgaigne as having occurred under the care of Boyer.† In this instance the whole bone was dislocated, both at the upper end and at the ankle joint, and was driven upwards.

Causes.—The cause of this accident would appear generally to be direct violence applied to the upper part of the bone. Thus, more than one case has been recorded where the injury has resulted from the passage of the wheel of a heavy waggon over the limb. But it may also be caused in other ways, as by the violent contraction of the biceps muscle. Mr. Bryant believes that it is "generally caused by some violent adduction of the foot with abduction of the knee, the head of the fibula tearing through its ligamentous attachments and becoming displaced outwards. Mr. Erichsen records a case in which it occurred in a gentleman, who in descending an Alpine slope covered with snow, fell with one leg bent forcibly under him.

When the bone is dislocated forwards, the head of the fibula is thrown on to the anterior surface of the outer tuberosity of the tibia to the outer side of the ligamentum patellæ. In the dislocation backwards the head of the bone is thrown backwards off its

* *See* a case, *Dublin Journal of Medical Sciences,* vol. xxxiv., p. 231.

† "Mal. Chir.," vol. iii., p. 883.

articulating surface, and rests against the posterior surface of the outer tuberosity of the tibia.

Symptoms.—The signs of this accident are well marked, for the injury can readily be recognised by the projection of the bone in its new position. The limb is usually semiflexed, and the power of extension and flexion is much impaired, sometimes entirely lost; though, in a case recorded by Bransby Cooper, the power of extension was perfect, and flexion could be performed to a considerable extent. Upon tracing the fibula upwards, it will be found to pass in front or behind its normal position and to terminate in the displaced head, which will be readily recognised forming a distinct and movable projection, either in front of the joint near the edge of the ligamentum patellæ, or behind in the popliteal space beneath the outer head of the gastrocnemius muscle. There is a flattening on the outer side of the leg, and a depression in the normal position of the head of the bone. The tendon of the biceps is rigid and tense.

Treatment.—The reduction of the displacement is seldom attended by any difficulty, the head of the bone usually returning to its place by means of pressure applied directly to it, after the knee has been bent in order to relax the biceps muscle. Owing, however, to the small size and want of adaptation of the articular surfaces, the greatest difficulty will be experienced in maintaining the bone in position, and a recurrence of the displacement frequently occurs. It often happens, therefore, that patients who have suffered from this injury recover with a certain amount of permanent deformity. This need not occasion them any distress, since it does not appear to produce any great inconvenience or weakening of the limb to any considerable extent. After reduction a compress is to be applied to the head of the bone, and firmly retained by a bandage or webbing. The limb, at the same time, is

to be flexed so as to relax the biceps muscle, and maintained on a splint for about three weeks. After this the knee should be put up in a moulded pasteboard splint, and the patient allowed to get about.

Dislocation of the Ankle Joint.

The ankle joint is a very powerful and strong articulation, and great force is required to produce dislocation; in the majority of cases, at all events of the more frequent (the lateral) dislocations, fracture is a necessary accompaniment of the injury.

Nevertheless, dislocation does frequently occur, on account of the great exposure to injury to which the ankle joint is liable, and these luxations may take place in five different directions, which are here enumerated in their order of frequency; viz. outwards, inwards, backwards, forwards, and upwards.*

The lateral dislocations: outwards and inwards.—The term *lateral* dislocation is somewhat misleading, since in this joint the displacement in a horizontally lateral direction rarely takes place. Such a displacement as ordinarily occurs, for instance, in the elbow joint; where the radius and ulna are displaced horizontally outwards or inwards from the humerus, and which is known as ordinary lateral dislocation, is of very uncommon occurrence in the ankle joint. Here the astragalus undergoes a partial rotation round an antero-posterior axis drawn through its own centre, so that its superior articular surface, instead of being directed upwards, is inclined more or less inwards or outwards, according to the variety of

* It seems scarcely necessary here to mention that the same nomenclature is used as with regard to other dislocations, and that the distal bone is spoken of as being dislocated from the more proximal one; but perhaps it is advisable to do so, since considerable ambiguity occurs in surgical literature, in consequence of the same accident being described differently, according to the view taken of the part displaced.

the displacement, and the inferior surface in the opposite direction. There is, therefore, no great separation of the trochlear of the astragalus from the under surface of the tibia, but rather that the outer or inner margin of this surface is brought into contact with the articular surface of the tibia, and the whole foot, in consequence, presents a lateral twist either outwards or inwards, according to the variety of the dislocation. Nevertheless, a true lateral dislocation, in a horizontal direction, has in some rare cases been met with.

Causes.—This so-called lateral dislocation of the ankle joint is generally produced by violent and sudden twists or wrenches of the foot. A patient, for instance, jumps or falls from a height. Upon reaching the ground the foot becomes a fixed point, and the patient falling over to one or the other side, gives a violent wrench to the structures in the neighbourhood of the ankle joint. He thus sustains a fracture of one or both bones of the leg, and the force of the blow being continued, a dislocation of the tarsus outwards or inwards, as the case may be. Or in jumping or falling he may alight on one edge of the foot and not flat on the sole, owing to some inequality in the ground, and thus give his ankle a violent twist which may produce a "lateral" dislocation. Again, a patient in walking incautiously steps off the curb and falls with his foot doubled under him, a strain is given to the owel part of the leg and ankle joint, and fracture with lateral dislocation results.

Lateral dislocations may take place in a direction outwards or inwards, and either of these dislocations may be complete or incomplete. The outward dislocation is by far the more common, and when incomplete is commonly known by the name of "Pott's fracture." *

* Chirurgical Works of Percivall Pott, 1775.

In this dislocation the fibula is usually broken about two or three inches from its extremity, but the fracture may take place considerably higher, as much as five inches from the tip of the external malleolus. The fracture is produced by the eversion of the foot, and its rotation causing the astragalus to press against the tip of the external malleolus. The strong tibio-fibular ligaments prevent the displacement of the bone outwards, and thus constitute a lever of the first order, of which the ligaments form the fulcrum, and the bone gives way two or three inches above the joint at the end of the lever. (*See* Fig. 46, page 286.) According to Pott, in consequence of this forcible eversion of the foot, the internal lateral ligament, being violently stretched, invariably gives way. Very frequently, perhaps indeed more frequently, the bone gives way, instead of the ligament, as the result of this severe strain, and the internal malleolus is separated from the rest of the tibia, the deltoid ligament remaining intact. The astragalus undergoes the partial rotation spoken of above, so that its superior surface has an oblique direction with regard to the under surface of the tibia; its outer margin resting against the articular facet on the end of the bone, and its inner border being separated to a greater or less extent from the joint (Fig. 89). This gives an inclination outwards to the foot; so that, if the patient were in the erect position, the inner margin of the foot would rest upon the ground and the outer edge be raised. The inner malleolus, if unbroken, or the lower end of the upper fragment, if the malleolus has been fractured, projects under the skin.

Occasionally, but very rarely, the displacement in the outward dislocation is horizontal in direction, without any rotation of the astragalus. This may occur in two ways: (1) There may be no fracture of the fibula, but the inferior tibio-fibular ligaments may

be torn and the astragalus displaced directly outwards, pushing before it the lower end of the fibula, so that this bone becomes widely separated from the tibia; or (2) the external malleolus may be fractured below the point of attachment of the tibio-fibular ligaments, and the astragalus be displaced outwards, carrying with it the external malleolus, which has been separated from the rest of the bone. These dislocations are partial, the inner part of the trochlear surface of the astragalus resting against the outer part of the under surface of the lower extremity of the tibia.

Fig. 89.—Pott's Fracture.

The fibula has been fractured about four inches from its lower extremity. The internal lateral ligament has been lacerated. The astragalus has undergone a partial rotation outwards, so that its superior surface has an oblique direction with regard to the under surface of the tibia, and in consequence the whole foot is everted. (After Pott.)

Symptoms.—The ordinary dislocation outwards is readily recognised by the great distortion that exists. There is a peculiar twist of the foot, so that its outer edge is turned up and the inner one down, which constitutes a characteristic sign of this injury. In consequence of this change in the direction of the foot, if the axis of the tibia is continued downwards, instead of passing through the astragalus, it falls considerably to the inner side of this bone. If the internal malleolus has not been fractured it forms a marked projection under the skin, which is tightly stretched over it; or if it is broken off, the fractured end of the

upper fragment will be seen projecting under the skin, though not to the same extent, and the malleolus will be felt on the inner side of the foot with a depression between it and the prominent end of the upper fragment. On the outer side of the ankle, above the external malleolus, is a distinct depression where the two fractured ends of the fibula form a retiring angle with each other (Fig. 90). There is usually a considerable degree of lateral mobility in the ankle joint.

When the bones of the foot have been displaced horizontally outwards, the peculiar twist of the foot is not present; but its greatly increased breadth, the projection of the malleolus of the tibia on the inner side, and the depression on the outer side, are sufficiently characteristic of this accident.

Fig. 90.—Pott's Fracture.
The figure represents the deformity which is produced by Pott's fracture. (After Pott.)

Complete dislocation outwards.—The dislocations outwards, which have been here described, are partial; that is to say, there has not been a complete separation of the articular surfaces of the tibia and astragalus from each other. There may be also a *complete* dislocation where the articular surface of the astragalus is completely displaced from that of the tibia, and is thrown to the outer side and above it. This accident, which is a very rare one, is usually known by the name of "Dupuytren's fracture," this

surgeon having described a case which occurred under his care in the Hôtel Dieu, in 1816. In these cases the trochlear surface of the astragalus is completely displaced to the outer side of the bones of the leg, and, at the same time, drawn upwards. The fibula is fractured, and the tibio-fibular ligaments torn through; or, what is more probable, a small portion of the tibia, into which these ligaments are attached, broken off, since there is reason to believe that the bone would yield before these very strong ligaments would give way. The broken bones and ruptured ligaments now allow the strong muscles to draw the foot, which has already been displaced outwards by the force of the injury, upwards to the outer side of the bones of the leg, even to the extent of two inches, as in Dupuytren's case.

Dupuytren believed that the dislocation upwards was due to a separation of the tibia from the fibula. But in a case recorded by Mr. Thompson, the astragalus and outer malleolus ascended on the outer side of the tibia till it was stopped by the lower end of the upper fragment of the fibula. In this case the internal malleolus was torn off, and was held *in situ* by the deltoid ligament, the tibia being thus allowed to depart from its articulation with the astragalus.*

Symptoms.—Such a considerable displacement must of necessity produce very great deformity. There is enormously increased breadth of the ankle, with shortening of the limb. There is prominence of the lower end of the tibia and the internal malleolus on the inner side of the leg, the skin being tightly stretched and tense over them. The internal malleolus is also sunken below its natural level, reaching even as low as the sole of the foot. The outer malleolus, which is carried upwards with the astragalus, is prominent on the outer side of the ankle, and is

* *British Medical Journal,* vol. i., p. 919; 1880.

elevated together with the whole of the outer side of the foot above its natural level. Combined with these symptoms there is rotation of the foot outwards, a depression above the outer ankle, and crepitus will usually be elicited on moving the foot.

Dislocation inwards.—Dislocation of the tarsus inwards from the ankle joint is said by Sir Astley Cooper to be one of the most dangerous of all the dislocations to which the ankle joint is liable, on account of the fact that it requires greater violence to produce it, and is therefore attended with more bruising of the soft parts, more laceration of the ligamentous and tendinous structures around the joint, and probably a greater amount of injury to the bones.

The dislocation is associated with fracture of the tibia; sometimes only the malleolus is chipped off, but usually there is an oblique fracture running upwards and inwards from the articular surface to the inner border of the bone above the malleolus, separating this process and a portion of the shaft of the bone. The external lateral ligament is ruptured ; or more usually the external malleolus, to which it is attached, is broken off, and sometimes the lower end of the fibula is splintered. Not uncommonly the astragalus is also fractured. The deltoid and inferior tibio-fibular ligaments remain intact.

The displacement usually consists, as in the displacement outwards, in a rotation of the astragalus on an antero-posterior axis through its own centre, but in the opposite direction, so that the inner border of the trochlear surface of this bone rests against the under surface of the tibia, and the superior articular facet looks upwards and outwards. The displacement may, however, be in a horizontally lateral direction, and the whole bone slide inwards under the tibio-fibular arch, so that the outer part of the superior articular surface of the astragalus rests against the

inner extremity of the arch, or upon the lower end of the fractured shaft of the tibia, from which the internal malleolus has been separated.

The **causes** which produce this dislocation are the same as those which cause the displacement outwards, viz. violent twists or strains of the foot; but the force is applied in the opposite direction, so as to turn the foot inwards. The violence required to produce the dislocation is, however, much greater, and the tibia being a far stronger bone than the fibula, the accident less frequently takes place. The symptoms are the same, *mutatis mutandis*, as in dislocation outwards. There is inversion of the foot, so that its outer edge rests on the ground, the sole looks upwards and inwards, and the inner border is elevated. The external malleolus projects on the outer side of the ankle, beneath the skin, which is tense and stretched over it, and almost touches the ground. When the patient is in the erect position, there is a distinct depression on the inner side of the joint, corresponding to the fracture of the tibia, and crepitus, as a rule, is easily felt.

Treatment of lateral displacement.—In the majority of cases reduction can be accomplished without difficulty; sometimes, however, on the other hand, the greatest difficulty will be experienced, not only in effecting reduction, but also afterwards in maintaining the bones in accurate position. The mode of proceeding is first of all to flex the leg on the thigh and the thigh on the pelvis, in order to relax as much as possible the muscular structures, and then, an assistant grasping the leg near the knee, in order to make counter-extension, the surgeon seizes the foot with one hand over the point of the heel and the other over the dorsum of the foot, and makes steady traction directly downwards. He at the same time, by a lateral movement of the hands, conveys a gentle rocking

motion to the bones of the foot, and will generally succeed in restoring them to their natural position. He must not, however, expect them to recede into their normal state with a sudden and audible "snap"; as in most other dislocations, the reduction will be effected gradually, and he must judge of its accomplishment by the restoration of the limb to its proper contour and appearance. Should the slightest difficulty be experienced, or the patient be nervous or complain of pain, it is advisable to administer an anæsthetic, and this will much facilitate the efforts of the surgeon. On many occasions where there has been difficulty in effecting reduction, or afterwards in maintaining the parts in proper apposition, I have found the greatest possible advantage from dividing the tendo Achilles. After reduction a pair of side splints, or if there is much swelling, a junk splint, should be applied, and when consolidation has advanced to some extent and all bruising disappeared, a fixed immovable apparatus can be worn until union has taken place. If any difficulty should arise in keeping the parts in position, the special treatment, as recommended by Pott or Dupuytren (page 288), should be adopted.

Antero-posterior dislocation of the ankle.—The antero-posterior dislocations of the ankle joint are not nearly so common as the lateral ones. The tarsus may be displaced either forwards or backwards. One would be inclined to believe, from the configuration of the joint, the mortise between the malleoli being wider in front than behind, and the articular surface of the astragalus being correspondingly shaped, that dislocation forwards would be a more common accident than dislocation backwards. The reverse, however, is the case. Dislocation backwards does occasionally occur, whereas the forward one is of very rare occurrence. Sir Astley Cooper states that he never saw a case. This greater frequency of the

backward dislocation is no doubt due to the manner in which the accident is caused in many cases, viz. by alighting on the feet in running or jumping. Under these circumstances the tarsus is forced backwards, or, what is the same thing, the bones of the leg are forced forwards, and therefore the dislocation is likely to occur; whereas the weight of the body is rarely brought to bear upon the joint in such a direction and with such violence as to force the bones of the leg backwards and produce a dislocation of the tarsus forwards.

Causes.—These dislocations are produced by some sudden arrest or fixation of the foot, while the leg is carried onwards. Thus it may be caused by a patient jumping from a height or from a carriage in motion, or it may be caused by some sudden violence applied to the limb while the foot is fixed, as in the case recorded by Prof. R. W. Smith, in which a sailor was struck by the falling of a heavy cask just above the knee, the leg being at the moment much flexed on the thigh and the foot on the leg.* The force of the blow was carried down the tibia to its lower end, and from the oblique position in which the bone was placed this was forced backwards on to the upper surface of the posterior part of the os calcis.

The antero-posterior dislocations may also, though not so commonly, be caused by violence applied to the foot while the leg is fixed.

Dislocation backwards may be complete or incomplete. In *complete* dislocation the trochlear surface of the astragalus is thrown behind the lower end of the tibia, which rests on the superior surface of the neck of the astragalus and the scaphoid bone. In the *incomplete* form, which, according to R. Adams, is the more common, the lower end of the tibia does not clear the articular surface of the astragalus, but the

* *Dublin Quarterly Journal Med. Sciences*, May, 1852.

posterior border rests somewhere near the summit of its trochlear surface, and the anterior border, advanced beyond its natural position, overhangs, without actually being in contact with, the scaphoid bone. By some authors it is stated that these dislocations may take place without any fracture. Under these circumstances, the lateral ligaments on both sides must be torn, as well as the anterior ligament of the ankle joint. Generally, however, the fibula is fractured above the malleolus, and the lower end displaced backwards with the bones of the tarsus, and often the internal malleolus is also broken, being torn off from the rest of the bone in consequence of the great strength of the deltoid ligament, which prevents it giving way.

Fig. 91.—Dislocation of the Bones of the Foot backwards.

The figure represents the deformity which is produced by a dislocation of the bones of the tarsus backwards from the ankle joint.

Symptoms.—There is great deformity of the foot and a marked appearance of shortening. In front of the ankle joint is a hard, prominent, transverse ridge, which is continued upwards into the leg as a marked elevation. The transverse ridge terminates in an abrupt margin; below and beneath it is a depression or sulcus, as if the skin were tucked in under the ridge. The toes are pointed downwards. Behind the joint is the prominence of the heel, which forms a marked projection, rendered the more distinct by a depression above it. The tendo Achilles is tense, and presents a somewhat curved outline with the concavity backwards (Fig. 91).

In the partial dislocation the symptoms are

identical with those above described, but are less marked. There is shortening of the foot, lengthening of the heel, and the projection of the end of the tibia on the dorsum of the foot.

Dislocation forwards may be either complete or incomplete. When *complete*, the articular arch formed by the tibia and fibula rests on the superior surface of the posterior part of the os calcis just in front of the tendo Achilles, in the position usually occupied by a mass of fat.* When *incomplete*, the anterior margin of this arch rests on the upper surface of the astragalus, somewhere near its posterior part, and may be fixed in this position, so that great difficulty is experienced in dislodging it, as in the case recorded by Mr. Poland.† The dislocation may take place without fracture either of the tibia or fibula. In Professor Smith's case alluded to above (page 496), the internal malleolus was broken off, but there was no fracture of the fibula.

Symptoms.—The deformity produced by this dislocation is considerable; the principal point which strikes the eye being an apparent elongation of the foot, and on actual measurement the distance from the instep to the toes along the dorsum of the foot will be found to be considerably increased; the heel is less prominent and pointed than natural, and the space in front of the tendo Achilles is filled by a hard swelling, which is easily to be recognised as the lower end of the tibia and fibula with their malleoli. The tendo Achilles is not so prominent, and does not stand out in such relief as in the natural position of parts. The displaced position of the malleoli at once establishes the diagnosis from transverse fracture of the lower end of the tibia or separation of its epiphysis.

* *See* two cases, one recorded by Demarquay, *Moniteur des Sciences Med.*, Oct. 1, 1861; the other by Willemin, *L'Union Médicale*, 1866.

† Guy's Hospital Reports, series iii., vol. i., p. 277; 1855.

Treatment of antero-posterior dislocations.—It is a curious fact, that whereas dislocation of the tarsus backwards at the ankle joint can usually be reduced with the greatest facility, writers who have described cases of dislocation forwards have usually complained of the great difficulty there has been in overcoming the displacement, and in some instances have found it to be impossible to do so. The cause of this is difficult to explain; there would seem to be no reason why the one should be more difficult than the other. In the case recorded by Mr. Poland, of forward dislocation, above referred to, the cause appeared to be the resistance of the tendo Achilles; for whereas no amount of extension, under chloroform, was sufficient to effect reduction; after division of the tendon the bones readily returned into position. The mode by which reduction is effected is identical with that which is employed in the lateral dislocations. The patient, lying on his back, has his thigh flexed on the pelvis and the leg on the thigh. The limb is firmly grasped just below the knee by an assistant, while the surgeon makes steady and firm extension from the foot, at the same time imparting to it a gentle see-saw movement, both in the lateral and antero-posterior direction; this serves to free the astragalus from its entanglements, and it will generally recede into position with an audible snap. If any difficulty should be experienced in accomplishing the reduction, it is advisable at once to resort to subcutaneous section of the tendo Achilles. After the displacement has been overcome, the joint must be put up in some fixed apparatus, of which, probably, a pair of side splints with foot pieces is the most convenient, and maintained at rest for two or three weeks, when passive motion may be commenced. Occasionally there will be found to be a great tendency to the recurrence of the dislocation after reduction. Mr.

Bryant has recorded two cases, one occurring in his own practice, the other in that of Mr. Cock; the difficulty was at once overcome by the division of the tendo Achilles.

Dislocation upwards.—In this form of displacement the inferior tibio-fibular ligaments are said to be ruptured, the tibia and fibula to be widely separated from each other, and the upper articular portion of the astragalus forced up between the two bones. It would scarcely seem possible for such an accident to take place, considering the strength of the ligaments; for not only must the inferior tibio-fibular ligaments be torn, but also probably the interosseous membrane and the strong lateral ligaments of the ankle joint, to allow such a displacement to take place. It would seem more than probable that the bones would scarcely withstand such violence as would be necessary to produce such a lesion, but that the bones themselves would break before the ligaments would yield. Nevertheless, cases have been recorded which leave no reason to doubt that such an accident may occur, and where competent observers have failed to detect any fracture. Such are the cases recorded by Sir William Fergusson,* Mr. Bryant† and Mr. Morris,‡ in which it would be difficult to believe that these skilled observers should have been mistaken in their diagnosis. The accident must be regarded as a recognised, but rare, lesion. At the same time it is probable that in most of the cases the injury will be found to be complicated with fracture of the bones of the leg or of the astragalus, as in a second case recorded by Mr. Bryant, in the same place. The injury would appear almost always to be produced in the same way, by falls from a great height on to the soles

* "Practical Surgery," p. 277. 5th ed.
† "Practice of Surgery," vol. ii., p. 388. 4th ed.
‡ "System of Surgery," vol. i., p. 1094. 3rd ed.

of the feet; from this cause the ligaments connecting the lower end of the tibia and fibula become torn, and the force continuing, the astragalus is jammed up between them.

Symptoms.—There is great widening and flattening of the foot. The malleoli stand out prominently on either side of the joint and are widely separated, the skin over them is stretched and tense. They are noticed also to approach much nearer the ground when the patient is in the erect position, the distance between their extremities and the level of the sole of the foot being perceptibly lessened. The relations of the astragalus are obscured, and the anterior margin of the lower end of the tibia well marked. There is an entire absence of motion in the ankle joint; the astragalus being firmly wedged between the two bones of the leg, so that even with the employment of considerable force it is impossible to move the bones of the tarsus on the tibia and fibula.

An attempt must be made to effect reduction, but it is very possible that this may fail, the astragalus being so firmly wedged in its new position that no effort will dislodge it. Such was the case in the instance recorded by Mr. Bryant, where the same injury had taken place in both extremities; the man, however, made a good recovery, though with stiff joints.

Reduction may be effected under an anæsthetic by forcible extension, which would tend to free the astragalus from the grip in which it is held, and, once freed, the bones would probably resume their natural position without difficulty.

Compound dislocations of the ankle joint.—No definite rules can be laid down for the treatment of compound dislocations of this articulation, as much will depend on the general condition and state of health of the patient, as well as on the local

condition of the injured part. Each case must be treated on its own merits. Formerly amputation was considered to be necessary in every case, now a large percentage of limbs are saved; some without any operative interference at all; others by resection of the ends of the bones. If the patient is young, his constitution sound, the vessels uninjured, and the wound not too large, probably no operation will be necessary; if, however, the wound is large and the bone projects considerably, it becomes a question whether we shall not give our patient a better chance of recovery, and with a more useful limb, by formally excising the joint, than by simply reducing the bones and attempting to procure its consolidation with the parts around. My own feeling is strongly in favour of excision under such circumstances. When the articular surfaces are comminuted, or the bones cannot be reduced by ordinary force, there can be no question that excision is imperatively called for. I have seen very admirable results follow primary excision of the ankle joint for compound dislocation in a case under the care of Mr. Henry Lee, in which the boy was able to walk five miles without inconvenience and with very little limp. Amputation is only necessary when the patient is old or suffering from constitutional disease or want of power which precludes the hope of obtaining a useful limb after excision, or where the soft parts are so extensively involved as to forbid the attempt to perform this operation. If the surgeon determine to make the attempt to save the joint, the wound should be carefully cleaned and every part of the joint thoroughly syringed with some antiseptic fluid, and free drainage provided for. The wound should then be closed, and firm and equable pressure made, the limb being fixed in a box (Assalini's or MacIntyre's) or on a back splint with a foot piece. Suppuration must be

carefully watched for, and any matter which forms at once evacuated. Anchylosis will probably result, but as a fair amount of motion may be obtained in the transverse tarsal joint, this will not prove the source of any great discomfort to the patient, and the limb will be, at all events, the same length as the other.

Dislocation of the Astragalus.

The astragalus is occasionally displaced from all its connections; from those of the bones of the leg above, and those of the tarsus below. It differs from the preceding dislocations in this, that whereas in those dislocations which have been previously described, the astragalus, though displaced from the malleolar arch, preserved its connection with the bones of the tarsus; in these cases it is not only separated more or less from the bones of the leg above, but from the os calcis and scaphoid below and in front.

The displacement may take place in either of the four directions, forwards, backwards, inwards, or outwards; or the bone may undergo a very peculiar displacement, being rotated on its axis, either horizontally, so that its long axis is directed across the joint and the head looks outwards or inwards, or it may be turned over sideways on its antero-posterior axis, so that the upper and under surfaces of the bone look inwards and outwards. The displacement is often conjoined with fracture, so that strictly speaking only a part of the bone is dislocated.

Dislocation forwards.—In this form of displacement, which is by far the most common, the astragalus is shot out forwards from its socket, though in the majority of cases the bone is not displaced directly forwards, but undergoes a partial rotation on a vertical axis, and is displaced obliquely forwards and

outwards or forwards and inwards, so that its head is inclined to one or the other side. It may be complete or incomplete. In the complete dislocation the bone is entirely separated from all its articulations, and may project prominently under the skin;* or, what is more common, the skin is lacerated and the bone protrudes from the wound. In some cases the dislocation is so complete that the bone is severed from all its connections, and if there is a wound may completely be thrown out of it, and, as in Norris's case, be found lying on the ground completely detached from the limb.

In the incomplete form, the astragalus is shot forwards from its articulations with the other tarsal bones, and having generally undergone a slight rotation, the under surface of the neck rests on the posterior superior margin of the scaphoid, either on its inner or outer part, according as the bone has been rotated inwards or outwards; while at the same time the posterior inferior edge of the astragalus is sunk in the interosseous groove between the two articular facets on the upper surface of the os calcis. In other cases, where the displacement is rather greater, the head of the astragalus rests on the cuneiform bones, and the groove on its under surface against the posterior superior margin of the scaphoid bone. At the same time the upper surface of the astragalus is displaced forwards from the tibia, so that if the displacement at this articulation is complete, the tibial arch rests on the upper surface of the os calcis; or else, if the displacement is partial, the anterior inferior margin of the articular surface of the tibia rests on the summit of the trochlear surface of the astragalus.

Causes.—These dislocations are generally caused by falls upon or twists of the foot, while it is extended

* *See* a case of Mr. Lane's; *Lancet*, vol. ii., p. 546; 1861.

upon the leg. If the foot is extended forcibly on the leg in the healthy subject, the head of the astragalus will be noticed to project prominently on the dorsum of the foot, evidently pressing upon and straining the not over strong astragalo-scaphoid ligament. Any violence applied while the bone is in this position would tend to rupture the ligament and force the head of the astragalus upwards from the concave facet on the scaphoid, and at the same time tearing the interosseous ligament between the astragalus and os calcis, separate the former of these bones from the latter. The force of the injury being continued in the same direction, would tend to separate the astragalus, which has now lost its support in front, from the tibial arch, and thus, dislocation of the bone from all its articulations would result, the particular kind of displacement that occurs depending upon the direction in which the foot was twisted at the moment of the accident.

Symptoms.—If the dislocation is complete, even though there is no wound, the symptoms are so unequivocal that no mistake in the diagnosis is likely to occur. The great prominence on the dorsum of the foot over which the skin is tightly stretched and tense, so as to exhibit the outline of the upper surface of the globular head of the astragalus, and the shortening, with approximation of the malleoli to the level of the sole, are sufficiently characteristic of this injury. Even in the incomplete form the symptoms are very marked. There is on the dorsum, either on the inner or outer side of the scaphoid, a rounded globular swelling, which under the tense skin is plainly recognised as the head of the astragalus. In addition to this, the trochlear surface of the astragalus forms a projection in front of the tibia, so that this bone seems more or less sunken and shortened. In consequence of the deflection of the head of the

astragalus inwards or outwards, the foot is turned in the opposite direction, and one or other malleolus is sunken, while the other one is unusually prominent. All movements of the ankle joint are abolished.

Dislocation backwards.—The astragalus, in rare instances, may be forced directly backwards from all its articulations, or, what is more common, may be forced backwards and outwards, or backwards and inwards. Sometimes the injury is complicated with fracture of the neck of the astragalus; the head of the bone then remains connected with the scaphoid, and the larger portion, or body, is alone displaced. In the direct backward displacement, the under surface of the astragalus rests on the posterior part of the upper surface of the os calcis, immediately in front of the tendo Achilles, so that the posterior surface of the bone presses upon the tendon, sometimes pushing it backwards, out of its normal position. When dislocated obliquely, backwards and inwards, or backwards and outwards, the astragalus undergoes a species of rotation as well, so that its superior surface, instead of being directed upwards, is oblique in direction and looks more or less inwards or outwards, and projects under the skin between the inner or outer malleolus and the os calcis, according as the displacement is internal or external.

Causes.—The accident is probably produced by severe violence or twists applied to the foot while in a condition of flexion. When the foot is acutely flexed on the leg, the neck of the astragalus almost reaches the anterior margin of the lower end of the tibia, and the posterior part of the bone is supported by the posterior fasciculus of the external lateral ligament, the posterior fibres of the deltoid ligament and the thin, narrow band passing between the posterior margin of the astragalus and the os calcis, which ligaments would be put on the stretch. If from

any sudden violence these ligaments are torn, the astragalus would be shot out backwards, and the interosseous and other ligaments connecting it to the other tarsal bones being ruptured, dislocation would result. The fact that displacement backwards is likely to occur when the foot is flexed at the ankle joint is rendered probable by a case recorded by Mr. Benjamin Phillips, where a gentleman, in running, placed his foot in a gutter, so that the toes rested on the farther edge and his heel was jammed violently down to the bottom of the gutter, the patient at the same time falling forwards.*

Symptoms.—In these cases there is not the same striking deformity as in the forward displacement. There is generally no eversion or inversion of the foot. The most marked sign is the presence of a hard prominence just above the heel, between the tendo Achilles and the malleoli; sometimes projecting beyond the heel, so that the tendon is pushed out of position and presents a convex outline. In those cases where the bone is displaced obliquely, the astragalus projects to one or other side under the skin, which is tightly stretched over it, so that its various articulating surfaces can usually be made out with the exception of the head, which remains buried under the tibia. The anterior border of the inferior extremity of this bone can generally be felt on the front of the joint, with a hollow or depression in front of it, from which the tibia has been removed. The movements of the ankle joint are lost.

Lateral dislocations of the astragalus.—Many of the cases which have been described as lateral dislocations of the astragalus ought, no doubt, to have been more correctly described as oblique dislocation forwards and outwards or forwards and inwards; but, nevertheless, true direct displacement

* *Medical Gazette*, vol. xiv.; 1834.

of the astragalus, outwards or inwards, does occasionally occur. Mr. Turner, in his monograph, has collected eight cases in which there was *direct* lateral dislocation of the astragalus; in four of these the bone was displaced outwards, and in four inwards. All were complete dislocations, and all were compound; and, in fact, it is difficult to understand how such a displacement could occur without at the same time being compound. It is doubtful, also, whether this dislocation can occur without fracture of one or other malleolus. Two or three cases have been recorded in which there has been no lesion of either of these processes, but it is very dubious whether these cases are to be regarded as complete displacements of the trochlear surface of the astragalus from the tibio-fibular arch, and not rather as cases of version of the bone without any absolute dislocation at this joint.

Version of the astragalus.—As we have before remarked, in the forward and backward dislocations there is often a certain amount of twisting or rotation of the bone. But there is another form of injury where the astragalus is turned more or less completely on its own axis, but at the same time remains *in situ*, no absolute dislocation taking place. The bone may revolve either on a horizontal or vertical axis. In the former case, the lateral surfaces of the astragalus look upwards and downwards, and the trochlear surface is directed to one or the other side, facing the articular facet on the inner or outer malleolus. In the other form, where the astragalus revolves on a vertical axis, the superior and inferior surfaces look in their natural direction, but the long axis of the bone is directed across the joint, so that its head faces the articular surface on one or the other malleolus.

Causes.—As Mr. Barwell has pointed out,* this

* Med.-Chir. Trans., vol. lxvi., p. 46.

accident occurs from violent strains or wrenches of the foot, when it is at right angles to the leg and in a position neither of extreme extension or flexion. For, as we have already seen, if the foot is hyper-extended, dislocation forwards results from the same form of accident; and if acutely flexed, dislocation backwards. Mr. Barwell has also very justly pointed out that there must be a certain relationship of strength between the ligaments of the ankle and those connecting the astragalus and os calcis. For if the latter be weak in proportion to the former, subastragaloid dislocation would alone occur, the ligaments of the ankle joint, on account of their greater proportional strength, escaping rupture, and thus maintaining the ankle joint intact. And, on the other hand, if the ligaments of the ankle joint were the weaker they would give way, and dislocation at this articulation alone result, the astragalo-calcanean joint escaping injury.

Symptoms.—The diagnosis of this peculiar form of displacement is involved in considerable difficulty, as there is no marked displacement or prominence of the astragalus whereby it may be recognised.

If the swelling is not great, the various processes or parts of the astragalus may be defined; but if it is, they will be so much obscured as to render them difficult of recognition. Then, the history of the accident, the loss of motion at the ankle, and evident severe injury without any of the prominences found in the ordinary dislocations of the astragalus, may lead the surgeon to a conjectural diagnosis.

Treatment of dislocations of the astragalus.—In all cases, where a dislocation of the astragalus has been diagnosed, an attempt must be made to effect reduction. If the dislocation is incomplete, this attempt will, in a large proportion of cases, succeed; if, on the other hand, the bone has

been completely displaced from all its articulations, it will probably not succeed, at all events, except in very recent cases. The reason of this is because the cavity or space between the tibia and fibula above, and the remaining bones of the tarsus below, from which the astragalus has been dislodged, has been partially diminished in size by the contraction of the muscles, especially those of the calf, drawing up the os calcis against the extremity of the bones of the leg. It will therefore generally be found necessary to overcome the action of these muscles by the subcutaneous division of the tendo Achilles. In order to effect reduction steady traction must be made on the foot, with the knee bent, the patient having been fully placed under the influence of an anæsthetic. If this should fail, the tendo Achilles, and any other tendon which may be felt on the stretch, should be divided, and the attempt renewed. If all efforts at reduction fail to accomplish the object, in simple dislocation the case is to be left alone. The limb is to be put up in some apparatus, of which probably the roll junk is the best; cold lotions or ice may be applied, and the issue of the case awaited. Sometimes things will go well, union will take place between the displaced bone and surrounding tissues, and the patient recover with a useful limb. This is certainly the case with regard to dislocations backwards, where suppuration or sloughing less frequently occurs than in the other forms, and where an exceedingly useful limb may be obtained. This was the case in a patient of Mr. Le Gros Clark, recorded by Sir William MacCormac, where the man twelve years after the accident had very considerable movement in the ankle, walked without the slightest lameness, and suffered no kind of inconvenience from the result of his serious injury.* Often, however, in cases of unreduced

* Path. Soc. Trans., vol. xxvi., p.176.

dislocation of the astragalus, sloughing of the skin over the prominent bone takes place, with profuse suppuration. In these cases, as soon as it is evident that sloughing will occur, the bone should be excised by an incision running parallel to the tendons and vessels, and the bone twisted out of its bed.

In cases of compound dislocation it is generally wiser to excise the bone at once, if the injury to the soft parts permits of this operation, or if not, to amputate. It may be justifiable in a young and vigorous adult, where the wound is small and the injury to the soft parts very slight, to attempt to save the bone by reducing the dislocation; but these cases are very exceptional, and the recovery after excision is so complete, and the usefulness of the foot is so perfect, that the surgeon would generally be acting more wisely by removing the bone when it has been detached from all its articulations, if the dislocation is compound.

Subastragaloid dislocation.—By the term "subastragaloid dislocation" is meant a displacement of the astragalus from its articulations with the os calcis and scaphoid. These dislocations have been, and are very liable to be, mistaken for those previously described, but differ from them in this essential particular, that the astragalus retains its connection with the tibia and fibula, and that the ankle joint is intact. This is of importance, not only as regards the diagnosis, but also the treatment, for it must be borne in mind that the bone is not, in these cases, severed from all its connections, and that, therefore, there are some points of difference in its surgical management which render its differentiation as a distinct injury an important point.

Subastragaloid dislocations are usually described as taking place in four directions; viz. backwards, forwards, inwards, and outwards. But, as a rule, the

displacement is oblique in direction, the foot being displaced backwards and outwards, or backwards and inwards from the astragalus; dislocation forwards, or forwards combined with lateral displacement, very rarely taking place. The dislocations are generally incomplete, at all events as regards the astragalo-calcaneum joint, some portion of the under surface of the astragalus remaining in contact with the articular facets on the upper surface of the os calcis. As regards the astragalo-scaphoid joint, they are usually complete.

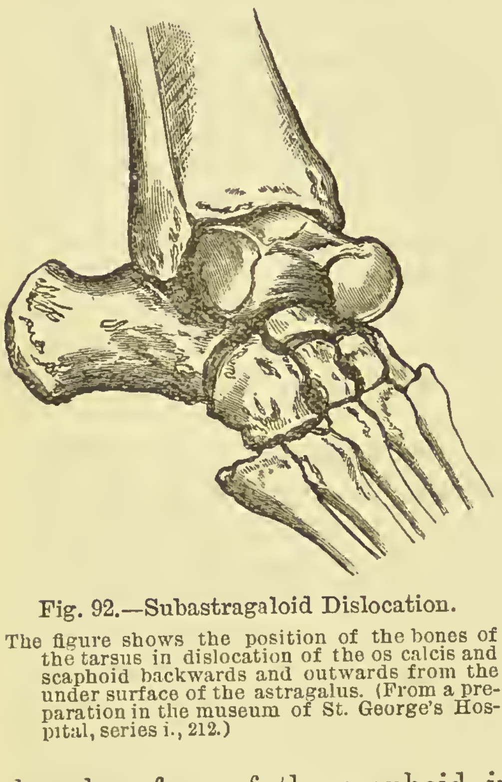


Fig. 92.—Subastragaloid Dislocation.

The figure shows the position of the bones of the tarsus in dislocation of the os calcis and scaphoid backwards and outwards from the under surface of the astragalus. (From a preparation in the museum of St. George's Hospital, series i., 212.)

In the more common dislocations, that of the tarsus backwards, combined with some lateral displacement, the head of the astragalus rests on the dorsal surface of the scaphoid, inclined to the inner or outer side of the bone; so that in the displacement of the foot outwards it rests on the superior surface at its junction with the internal surface just above the "tuberosity of the scaphoid" (Fig. 92), and, when the foot is displaced inwards, the head of the astragalus rests on the outer extremity of the dorsal surface of the scaphoid, or on the superior calcaneo-scaphoid ligament. The posterior border of the

inferior surface of the astragalus is lodged in the interosseous groove, between the two articular facets on the upper surface of the os calcis; or if a greater amount of displacement than this has taken place, the head of the astragalus rests, in front of the scaphoid, on the cuneiform bones, and its articular facets on the concave posterior surface of the scaphoid. In some rare cases the head of the astragalus may be dislocated from the scaphoid, with little or no alteration in the position of the articular surfaces of the body of the bone with the os calcis. Pollock and Arnott have both recorded cases where the head of the astragalus has been dislocated, without rupture of the interosseous calcaneo-astragaloid ligament, and therefore necessarily without any great displacement of these bones from one another. In a considerable percentage of cases the fibula is broken.

Causes.—These dislocations, like the other dislocations already described about the ankle joint and astragalus, are produced by violent strains or wrenches of the foot. But in consequence either of a greater strain being thrown on the ligaments which connect the astragalus and os calcis, or on account of their being relatively weaker than those of the ankle joint, they give way first, and the subastragaloid dislocation results, the ankle joint remaining intact.

Symptoms.—There is evidently a great deformity of the foot, which is shortened in front, elongated behind, and generally somewhat extended. The most prominent deformity is produced by the head of the astragalus, which appears as a globular swelling, with the skin tightly stretched and tense over it, either on the inner or outer side of the dorsum of the foot. In the dislocation outwards the foot is everted, so that its under surface is directed more or less outwards; the inner malleolus is prominent and well marked under the skin, and the outer malleolus buried, the os calcis

projecting beyond it. In the dislocation inwards the position of the foot is reversed; it is inverted, the sole looking inwards, the outer malleolus is prominent and the inner one buried. The diagnosis of this injury from dislocation of the astragalus may be made by observing the unaltered relation of the malleoli to the astragalus, and by the recognition of the fact that there is no shortening such as takes place in complete dislocation of the astragalus from approximation of the os calcis to the tibio-fibular arch, and that a certain amount of motion is permitted in the ankle joint.

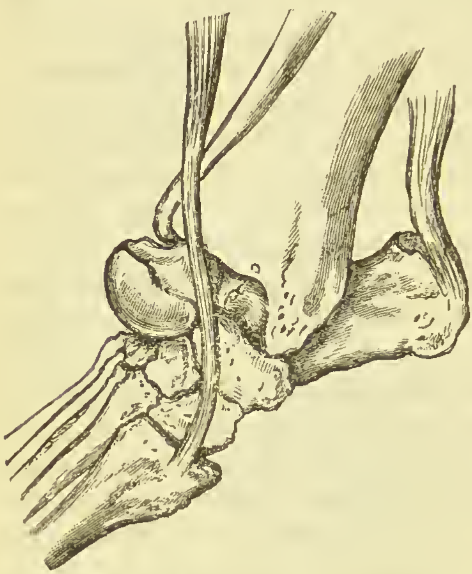


Fig. 93.—Subastragaloid Dislocation.

The figure shows the position of the bones of the tarsus in dislocation of the os calcis backwards from the astragalus. The anterior tibial tendon embraces the neck of the astragalus, and constituted an impediment to reduction. (From a preparation in the museum of St. George's Hospital, series i., 212 *a.*)

Treatment.—No one who has seen many cases of subastragaloid dislocation can fail to be struck by the great difference there is as regards the ease with which reduction can be effected. In some the bone returns to its place with the slightest amount of manipulation; in others, no efforts succeed in restoring the bone to its place. This difficulty appears to depend on several causes: in some, to the tibial tendons becoming hitched round the neck of the bone (Fig. 93); in others, to the sharp posterior margin of the under surface of the astragalus being lodged in the interosseous groove of the os calcis;

and, again, in others, to the under surface of the neck of the astragalus being wedged against the sharp posterior margin of the dorsal surface of the scaphoid.* Probably, also, where the astragalus is fractured, the broken portion of bone may prevent reduction.

The manner in which extension should be made in dislocation of the tarsus *backwards* from the astragalus is of importance. The extension should not be made, as is so often done, by pulling downwards, that is to say, by dragging the foot away from the bones of the leg, but by making extension forwards, that is to say, in the opposite direction to which the bones have been displaced. In order to effect this, a bandage is to be firmly fixed around the fore part of the foot, just behind the heads of the metatarsal bones, and then to be tied over the shoulders of the operator, as he kneels over his patient, with one knee in the concavity in front of the ankle, pressing against the lower extremity of the bones of the leg. By raising the trunk the surgeon is able to make forcible extension, and at the same time has his hands free to manipulate the bone into its place. If this should not succeed, the same plan of treatment must be adopted as in dislocations of the astragalus. The tendo Achilles and any other tense tendons must be divided and the attempt renewed. On the failure of these measures the foot must be left to itself, and excision performed if active inflammatory mischief supervene. In compound dislocation, excision or amputation, according to the amount of lesion of soft parts, will in most cases be called for.

Dislocation of the other tarsal bones.—The tarsal bones, on account of their spongy character, are more frequently broken, as the result of violence, than dislocated. Nevertheless, dislocation does occasionally occur, and cases have been at various

* *See* a case by the author, Clin. Soc. Trans., vol. xiii., p. 132.

times recorded of displacement of one or more of these bones; they must be regarded, however, more in the light of surgical curiosities than of well marked and recognised injuries. Perhaps one of the most common is the "medio-tarsal" dislocation, described by Sir Astley Cooper, where the anterior tarsal bones are dislocated from the os calcis and astragalus. The displacement may take place either laterally or upwards or downwards. Single bones may be dislocated: the os calcis, laterally; the scaphoid, or the internal cuneiform. The cuboid is said to be never displaced alone. Or more than one bone may be dislocated; for instance, the three cuneiform;* or the internal cuneiform may be displaced and carry with it the first metatarsal bone, or, indeed, all the metatarsal bones.

The symptoms are generally obvious, the prominence of the displaced bone or bones indicating the nature of the lesion. And extension, combined with pressure on the prominent bone, will generally succeed in effecting reduction.

Dislocations of the metatarsal bones likewise occasionally occur. Either one, more, or all these bones may be dislocated. The displacement may occur in any of the four positions, upwards, downwards, inwards, and outwards; dislocation upwards being the most common. In some instances, one bone may be displaced upwards and another downwards. The accident is usually caused either by falls from a height, or by a heavy wheel passing over, or weight falling on to, the foot. The shortening of the toes and the prominence of the displaced bones indicates the nature of the injury. Extension and pressure under chloroform generally succeeds in effecting reduction; should it not, however, succeed, a fairly serviceable foot may be confidently anticipated.

* *See* New Sydenham Biennial Retrospect, p. 254; 1873.

In a paper in the *Berliner Klin. Wochenschrift*,* Dr. Hitzig considers these dislocations. He has collected twenty-nine cases, including some of dislocation of the entire metatarsus, others of a single bone, and, again, others where two or more bones were luxated. He states that if the dislocation can be reduced at once, the prognosis is good; and even when the dislocation is irreducible, if the displacement is in the vertical direction, little loss of function need be apprehended; but when the displacement is sideways the foot is not so useful. He dissuades too energetic attempts at reduction as not free from danger, and recommends manual extension and counter-extension with pressure of the thumbs on the displaced bones, chloroform having been administered, and states that in his opinion this is the method most likely to succeed.

Dislocation of the phalanges is a rare accident. That of the proximal phalanx of the great toe is the most common, and, like the corresponding dislocation in the upper extremity, often extremely difficult to reduce, and probably owing to the same cause. They present nothing of a special character either as regards their nature or treatment.

* The paper is abstracted in the New Sydenham Society Biennial Retrospect for 1867, p. 274, from which these remarks are obtained.

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